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NEW YORK, SEPTEMBER, 1894.

EDITORIAL NOTES.

THE fact that it is possible for a sea-going vessel to go from the Gulf of St. Lawrence to the Great Lakes by way of the Canadian canals has served as a spur for a number of years to the congressional representatives of the States bordering on these inland seas to press the construction of a ship canal from the lakes to the sea in the territory of the United States. A bill to secure an appropriation sufficient for a preliminary survey is now before the House, but its chances of passing are exceedingly slim, owing to the facts that the amount ($100,000) would be a mere bagatelle as compared to the total expenses and that now is the era of retrenchment.

IT is almost startling, when we remember that in 1887 the first really commercially successful electric railway was started in Scranton, Pa., to read that articles of incorporation for a network of electric railways that will connect Jersey City and Philadelphia have been filed. There is no reason why such roads should not be built, for the whole distance is dotted with thriving towns, like beads on a string, and the constant desire of man to be somewhere else than where he now is leads him to patronize the trolley and go to the next town. A similar system of interurban roads already exists in the coal regions of Scranton and Wilkesbarre, and it is doing a thriving business. How long it will be before these roads can compete with the steam lines for through passenger and all freight business the future alone can tell.

WE wish to call particular attention to our report of accidents to locomotive engineers and firemen for the month of July that appears in another column. Out of the 50 accidents that are reported, there are 11 that are attributed to train wreckers and strikers. In every instance but one they were credited to the account of the strikers. In these 11 accidents six engineers and four firemen were killed, and four engineers and three firemen injured. It is poor consolation for the families of these men to know that they were killed and injured in the performance of their duty. It was a case of mob violence, exerted by one set of men against their mates, unreasonable and unreasoning, and the results have been so disastrous, and so many innocent people have been made the victims of this blind wrath, that there seems to be many very good reasons for classing attempts at train wrecking with murder in the first degree.

NEWS of the battles that have taken place between the Chinese and Japanese during the existing state of unpleasantness is so exceedingly meager that we really know almost nothing about them. But viewed through the mist that shrouds operations on the Asiatic coast, it would seem that the personal equation is quite as important a factor in the sea fights conducted with turreted battle ships as it was in the old struggle against the Spanish Armada in the English Channel. The know-how and the vim seems to count; and while the Japanese navy seems confessedly weaker than that of their opponents from the standpoint of armor and armament, they appear to be getting the best of it. As this is the first war that has given an opportunity to test the modern war ship's capacity as a fighting machine, the engineering world will watch with interest the development of the relative values of guns, armor, torpedoes and the ram.

THE remarkably clear comparison of the working of locomotive, stationary and marine engines published in another column should go far toward straightening out the entanglement of ideas that now prevail regarding the use of the compound locomotive. The facts, briefly stated, seem to be that for the economical consumption of steam the locomotive compares favorably with both marine and stationary engines of the same type, and that the compound will effect a saving over the single expansion locomotive when it is worked under a higher steam pressure. In the dispute over the compound-single-expansion question, the use of the higher pressures by the compounds has been claimed to give it an unfair advantage over the single expansion. M. Desdouits, however, claims to have proven that these high pressures can only be economically used in connection with the compound engine, and it therefore has a right to use them in any and all competitive trials.

A DECISION has recently been rendered by an English court that to us has the appearance of a decided novelty in the standpoint taken relative to the liability of railroads for damages. A train of the Midland Railway Company was timed to start at 5.18 A.M. The plaintiff, who was a miner, took a ticket to travel by that train to his work. He waited at the station until 7 A.M., when the train had not then arrived. As at such time it was too late to be allowed to go down the pit to do that day's work, he went home. He brought an action against the railway company to recover the day's wages he thus lost. The Court of Appeal decided that as there was unreasonable delay in starting the train the plaintiff was entitled to recover. In view of such precedent, it would be interesting to see what stand an American court would take, and whether the fact of habitual tardiness would be detrimental to the company's case, especially where it protects itself with the notice that the "company reserves the right to change the time of any or all of its trains without previous notice, and only posts this time-table for the convenience of the public to show when trains may be expected." It would probably be diffi-

cult to collect damages from a company shielded behind such a notice and defended by a shrewd lawyer, who would take advantage of every technicality; and yet there should be some redress, for in selling a ticket the company virtually agrees to perform a certain service at a certain time, which, in the case of a delayed train, it does not do.

THE PROCEEDINGS OF THE MASTER MECHANICS' ASSOCIATION.

Reviewing the proceedings of a number of meetings, like those which the Master Mechanics hold annually, is a little like writing history, in that it is not easy to regard the events which have transpired, the facts which have been adduced, the theories and arguments which have been advanced as calmly and dispassionately at the time the events are occurring, or immediately after, as is possible when the whole proceedings are condensed into one volume, and are in a convenient form for reference and study. The report of the twenty-seventh annual convention, which was held at Saratoga Springs in June, has now been received, and invites examination, comment and criticism.

The first observation which suggests itself is the very neat cover which the Secretary has designed and in which the volume is bound. It is of a pale green color, with the title printed in what in schoolboy days we called "old English" type, below which is a skeleton view in outline, with the main parts represented in a gray tint, of the Baldwin compound engine *Columbia*, which was exhibited in Chicago. The Baldwin Company, it is thought, has never done this engine full justice in the photographs and other illustrations of it which they have published. These have all been "quartering" views, looking toward the front of the machine, and remind one of the pictures in the illustrated papers of the new prince, recently acquired in England, whose head is made the prominent object in the portraits. These and the photographs of the *Columbia* make one think of those embryonic creatures which consist principally of head. It is hardly necessary to add that this impression is an unfair one both for the prince and the *Columbia*. Mr. Sinclair has given us a full side view or elevation of this locomotive which indicates its impressive proportions, although very few details are shown.

The President, in his annual address, pointed out that, owing to the general depression in business, the most urgent duty resting on the members of the Association is the reduction of the cost of operating locomotives, and many of our readers will probably sympathize with him when he speaks of "the incomprehensible policy of rate cutting."

The reduction of fuel consumption, he points out, is the direction in which the greatest economy may probably be made; and the compound locomotive, he thinks, offers the most hopeful means of attaining such economy. Next to this source of saving, increased facilities and conveniences for making repairs is the direction in which locomotive superintendents must look for a saving.

He had a good word to say for the work of the various railroad clubs which hold their meetings at different places during the year, and suggests the amalgamation of the Master Mechanics' and Master Car Builders' associations—a proposition which comes up annually, but which this year was opposed by some of the supply dealers, who objected to lessening the period of time during which they can exert their influence on the members of the two associations.

The President also suggested that the time has arrived when the associations should consider the question of making arrangements with some established institutions of learning whereby the co-operation of its professors and the use of its scientific apparatus for the investigation of technical subjects could be obtained. The Secretary afterward reported the results of his efforts to raise a fund of $5,000 for making tests of locomotives, which failed owing to the hard times, although he seemed to entertain the hope that when "the clouds roll by" the scheme might succeed. He reported that most of the railroad presidents with whom he had interviews advised that the enterprise be abandoned for the present. Later in the proceedings a committee was appointed, on motion of Mr. Lauder, to suggest what action should be taken to secure the co-operation and aid of the American Railway Association in getting funds for making such tests. This committee afterward made a report, and recommended that another committee of three be appointed to confer with the American Railway Association with reference to this subject, and that a committee of five be appointed "to outline work and to conduct and supervise such tests as may be decided upon." Such committees were appointed, and have authority to take action.

There was also a very elaborate report made by another committee, appointed last year, on Standard Tests of Locomotives, and which occupies 25 pages of the printed proceedings. In this dissertation the committee describe very elaborate methods of making such tests, and give in great detail the data which should be ascertained. After discussion the report was adopted as one of the standards of the Association. It is not quite clear what the significance of this action is. Does it mean that, if any one undertakes to test a locomotive, they are recommended to do it in the manner described by the committee? This seems to be very much as though an association of doctors should get together and adopt a standard method of diagnosing disease. In making experimental investigations we generally want to learn the cause of some phenomena or deficiency which we don't understand and can't explain, or learn something which we don't know. The success of an experimenter in making discoveries depends very often on his ingenuity, his skill or the acuteness of his reasoning powers in making deductions from not only the facts which he observes, but in the detection of facts which should be observed. The experimental investigations which give the most valuable results are not those which follow beaten paths, but those which depart from them and adopt new and original lines of research and new expedients for increasing knowledge. Standardizing methods of scientific research and discovery seem to be a sort of Chinese way of finding out things which we don't know. The report contains many very excellent and valuable suggestions with reference to the testing of locomotives, but it is difficult to see any good reason for making them standard methods.

Mr. Barnes called attention, too, to the fallacy of referring the consumption of coal to the dynamometer H.P., which is recommended in the report for the reason that the work done by a locomotive is not only that required to pull the cars, but it must also pull itself and its tender. The amount of fuel consumed in doing this was shown by the test which Mr. Buchanan made and which is reported on another page. There is, of course, a rate of ascent on which a locomotive could only pull itself. In such a case, while it might in every way be working very economically, no power at all would be developed on the dynamometer, and yet by the action of the Association that way of estimating coal consumption is now the "standard" way.

The substance of the report of the Committee on Cracking of Back Tube Sheets is summed up in their deductions from the replies to their circular of inquiry, in which it is said: "First, that radial stayed boilers carrying high pressure are more subject to cracked tube sheets than other types." The cause of this is assigned to too rigid staying of the crown sheet next to the flue sheet, placing flue holes too close to the flanges and possibly to too high steam pressure. The cure proposed in the report and in the subsequent discussion is to

allow more flexibility in the crown sheet directly back of the tube sheet either by placing the stay bolts further back or putting in a different kind of stay next to the tube sheet, which will allow it and the crown sheet to expand upward without straining the stays. There was nothing very new evolved by the discussion, but it confirmed what has long been known, that the fire-box is the most troublesome part of a locomotive.

The report of the Committee on Oiling Devices for Long Runs had nothing that was very noteworthy. It describes with considerable detail the practice on a number of English and American roads, and has an appendix added on Oils and Oil Tests.

The report on Boiler and Fire-box Steel excited much interest, as the committee proposed standard specifications to be adopted by the Association. The main question at issue seemed to be the ultimate strength which fire-box steel should have. Some of the members favored a soft steel with an ultimate strength ranging from 50,000 lbs. to 58,000 lbs., while the majority preferred a harder quality, with an ultimate strength of 55,000 lbs. to 65,000 lbs. In their efforts to get positive information concerning the performance of hard and soft fire-box plates, the committee had tensile tests made of specimens of steel both before and after service. This strength varied from 77,000 lbs. down to a little over 50,000 lbs., and the mileage service from a little under 500,000 miles to a little over 50,000 miles. In the discussion which followed, Mr. Gibbs, of the Chicago, Milwaukee & St. Paul Road, said that they had tabulated the results of the service of about 250 fire-boxes on his road, and that in one class of engines the highest mileage of any fire-box, which was a little less than 500,000 miles, was given with a 77,000 lbs. steel. In another case he found that in one of the fire-boxes which gave nearly the highest mileage the plates had phosphorus as high as .13, whereas they were specifying .035, and they found in a great number of the old fire-boxes that gave splendid service "chemistry that seems perfectly wild." The committee concluded, however, that the weight of evidence was in favor of steel of 60,000 lbs. tensile strength giving the best results. The following are the standard specifications which were recommended by the majority of the committee, and were finally adopted excepting as indicated in the foot-note, and are probably the specifications to which manufacturers will be obliged to conform hereafter:

Metal is to have tensile strength of 55,000 lbs. to 65,000 lbs., with 60,000 lbs. desired, and 28 per cent. elongation preferred.

The chemistry desired is:

Carbon	.18
Phosphorus, not above	.03
Manganese " "	.40
Sulphur " "	.02
Silicon " "	.02

Plates will be rejected having:

1. Tensile strength less than 55,000 lbs.
2. Tensile strength over 65,000 lbs.
3. Elongation less than 22 per cent. in 8 in., and in ½-in. plates not less than 20 per cent. in 8 in.
4. Failure to stand bending and quenching test as for shell steel.
5. Any seam or cavity more than ¼ in. long in any of the fractures of homogeneity test.

CHEMICAL.

Carbon	.25
Carbon, below	.15
Phosphorus, over	.045*
Manganese "	.45
Silicon "	.03
Sulphur "	.035

* This, on motion of Mr. Mitchell, was changed to .035.

Homogeneity test is made in the following manner:

A portion of the broken test piece is nicked with a chisel on opposite sides alternately, nicks being about 1 in. apart. Test piece is then firmly held in vise and broken by a number of light blows, bending being away from the nicks.

Laminations more than ¼ in. long to condemn.

During the discussion some curious statements were made. Mr. Vauclain, for example, recommended that every master mechanic should employ a chemist and start a laboratory, and said that they could hire a chemist for a great deal less money than they can hire a good mechanic, and that after they have had him a short time and have found out the value of such a man they would be willing to pay him the best wages paid about the establishment.

Mr. Dean thought that the elastic limit in steel should not be ignored, to which Mr. Gibbs, chairman of the committee, replied that the reason they did not specify anything on the subject of elastic limit was, first, that they did not know anything about it; secondly, the strains that they designed for were 14,000 lbs. per square inch, and that is so far below the elastic limit for any steel they knew of that they did not think it necessary to discuss it. This "reminds us of a little story" current in the daily papers recently of the man who said he had just met a *great* physician. His friend asked how he knew he was a distinguished doctor. "Why," he said, "I asked him what was the best cure for consumption, and he said he didn't know."

Mr. Gibbs added further to the discussion the statement that he had been unable to find any difference whatever in the service of steel of 50,000 lbs. and 60,000 lbs. ultimate strength in regard to the life of the sheet. Mr. Forsyth, of the Chicago, Burlington & Quincy Railroad, confirmed this by the statement that he thought "the tendency is to think that if a fire-box sheet cracks the steel is of high strength and high carbon; but he thought the results of a great many tests have shown that soft steel—low-strength steel—is just about as liable to crack as high steel."

The report and discussion have shown that the members of the Master Mechanics' Association do not know all that it is desirable should be known about fire-box steel, and that the fire-boxes are still, as they have always been, the most costly parts of the machine to construct and the most troublesome and expensive to maintain. To be rid of the troublesome steel plates, which behave so badly, would be a great boon.

It was intended, when this review of the proceedings of the Master Mechanics' Association was commenced, to complete it in one article, but about a half of the report of the proceedings, including the interesting discussion on compound locomotives, still remains. Our review must, therefore, be divided into two parts, and the publication of the conclusion be postponed to our October number.

NEW PUBLICATIONS.

THE CAR INTERCHANGE MANUAL. *A Compendium of Useful Information for Master Car Builders and Car Inspectors, Including an Abstract of the Decisions of the Arbitration Committee of the Master Car Builders' Association.* Compiled by J. D. McAlpine. Published by the *Railroad Car Journal*, New York. 86 pp., 8¾ × 5¾ in.

The title gives a very good description of the general character of this book. It is composed chiefly of abstracts of decisions of the arbitration committees of the Master Car Builders' Association subsequent to May, 1888, of disputes arising under the rules for the interchange of cars. What is of equal value to these decisions is an excellent index to them. The decisions are followed by a table of words often misspelled on defect cards of car reports; a table of synonyms of parts of cars known by different names; table showing the depreciated value of $100 at 6 per cent.; settlement prices for cars destroyed; various tables and useful data, and what to do in

accidents and emergencies. Altogether it is, for those for whom it is intended, a very useful little book, and the work of compilation has been well done.

Universal Index to the World's Technical and Scientific Literature. Section I, Nos. 1, 2 and 3, and Section II, Nos. 1, 2 and 3. Leipzig: Heinrich Wien, Editor. Each number 16 pp. 8¼ × 12 in.

A few extracts from the announcement of this publication will give an idea of its general scope, purpose and character. In this the editor says:

"The *Universal Index to the World's Technical and Scientific Literature* will make it its aim to be a faithful and reliable *weekly chronicle* of the entire literature of every branch. It will be provided at the close of every year with a carefully prepared *index of authors and subjects*, so that the annual volumes will, in course of time, form an indispensable work of reference for every library.

"The *Universal Index* deals at the outset with the following departments:

"Section I.—1. Architecture, Building Trade and Building Industry. 2. Engineering. 3. Technics, Machines and Appliances and Engineering Industry. 4. Electro-technical Science and Industry.

"Section II.—1. Mining and Metallurgy. 2. Railways. 3. Chemistry and Physics. 4. Chemical Industries. 5. Brewing and Distilling Industries.

"Section III.—1. Iron, Steel and Hardware Industries. 2. Miller's Industry. 3. Paper Industry. 4. Photography. 5. Textile Industry. 6. Sugar Industry.

"As a rule, we propose, in the first place, to take note of the *original articles* published in the journals, but we shall also register the smallest communication, if only it appears to us to possess any special *professional interest*.

"The 'New Books' noticed in the *Universal Index* will be found united in one group for all the divisions of a section. This will cause no difficulty or inconvenience to the professional man. Our attention will be directed not only to the new books published from week to week, but above all to *works still in the press*, so that a reader of the *Universal Index* will always be able to order any interesting work without delay."

The editor adds still further that, "in course of time the *Universal Index* will deal successively with every existing department in the same manner."

This seems a little like the scheme of one of Bulwer's characters, who was engaged in writing "a history of human error."

As far as the work before us has gone, it can, however, be very highly commended. The title of the publication and of each article indexed are given in the language in which they were originally written, and the columns thus have a sort of polyglot character. As an example of the way the work is done, we may select from the matter given in Section I, Part 1, under the head "Engineering," where substantially the index which was published on the front page of the cover of the American Engineer and Railroad Journal for June, of this year, is reprinted under that title as a sub-heading. Just preceding this are similar titles taken from the *Revista Minera Metallurgica y de Ingeneria*, of Madrid, all printed in Spanish.

Owing to the enormous growth of technical literature, some systematic method of indexing it is becoming daily more essential, and probably one of the greatest assistants in acquiring knowledge in the future will be good indexes.

The editor says that in order to bring the *Universal Index* within the reach of all, the price of the section (II) now ready has been fixed at 3 marks per quarter. It should be added that it is intended to publish it weekly, and that the editor, whose address is given above, appears also to be the publisher.

Aerial Navigation. By J. G. W. Fijnje Van Salverda, late Administrator of Public Works of the Netherlands. Translated from the Dutch by George E. Waring, Jr. With notes concerning some recent development in the art. Illustrated. 12mo, cloth, $1.25. D. Appleton & Co.

It is interesting to note that a number of well-known engineers, whose past career has given evidence of soberness and soundness in judgment, are now turning their attention to the problem of aerial navigation.

We have lately published a book upon "Progress in Flying Machines," by Mr. O. Chanute, past President of the American Society of Civil Engineers, and now we have for review a book upon "Aerial Navigation," by Mr. Fijnje Van Salverda, which has been translated from the Dutch by that well-known and distinguished American sanitary engineer, Mr. George E. Waring, Jr., who says of his author that he is "a most distinguished Dutch engineer, of advanced age, and now retired from the public service, in which he held the highest position."

The book comprises some 200 pages and an index, and consists chiefly of an investigation of the probable success in the free navigation of the air. It is necessarily somewhat indefinite as treating of an achievement which is merely *in passe*, but it is well worth reading by engineers.

The author begins by giving an account of what has been accomplished with balloons. He devotes his first chapter to a consideration of The Military Importance of Aerial Navigation, and treats of both captive globular balloons for observation and of elongated free balloons for reconnoissance over the enemy's lines. He shows that with the latter a speed of some 14 miles per hour has been obtained by the French, and that, with certain improvements, a velocity of 28 miles an hour is not improbable. This, of course, is in still air; but a table of wind velocities is given as observed at Châlon by means of a self-registering anemometer placed at the top of a mast 90 ft. high, from which it appears that with the above speed the free navigation of the air will be practicable for 50 to 70 per cent. of the days in the year. He does not, however, indicate the formulæ by which the speeds may be calculated for various shapes of balloons or for various horse-powers, nor the probable commercial uses of navigable balloons, but he reaches the conclusion that "the magnificent aim of navigating the air with balloons may not yet be reached, because they cannot be propelled with sufficient velocity to meet all conditions of wind."

Mr. Fijnje, therefore, next turns his attention to dynamic flying machines heavier than the air which they displace, and devotes several chapters to the flight of birds and its various phases—rowing, gliding* and sailing. These are discussed, as well as the changes which occur in the position of the center of pressure under the wings of birds (law of Avanzini), and after two brief chapters upon The Exertion of Force by Birds, and Atmospheric Currents, a discussion is entered upon of the various appliances—the screw, the beating wing and the aeroplane—with which man has endeavored to imitate the birds. From this discussion the inference is drawn that the aeroplane offers the best chance of success, and the author observes, "that rapid travel in the free air need encounter no serious difficulty!"

The remainder of the book consists in extracts from a later pamphlet by Mr. Fijnje, reviewing the experiments in aerodynamics of Professor S. P. Langley, which are held to be in remarkable agreement with the former conclusions of the author; in an account of the article of Mr. Maxim in the *Cosmopolitan Magazine*, and full extracts from the article of Mr. Hallam in the same magazine, as well as of a subsequent article by the same writer in *Cassier's Magazine*.

The concluding chapter is upon The Soaring of Birds and of Men, as suggested by the paper of Professor Langley on The Internal Work of the Wind, read at the Conference on Aerial Navigation at Chicago, in August, 1893, which has been published and discussed in Aeronautics.

The book is written throughout in popular style, with few or no formulæ and calculations, and is chiefly valuable as indicating the probability of success from the standpoint of an experienced engineer. There is no reference to the experiments of Lilienthal, or to those of his predecessors in soaring flight, and it is to be hoped that with the new material accumulated within the past year we shall be favored with another book by the author.

Pocket Primer of Air-Brake Instruction. By W. S. Rogers, M.E., Air-Brake Instructor Delaware & Hudson Canal Company. 90 pp., 4¼ × 6 in.

Diseases of the Air Brake System, *their Causes, Symptoms and Cure*. By Paul Synnestvedt. 114 pp., 5¼ × 7¾ in.

That the construction and operation of the air brake is not easy to understand is indicated by the number and character of the attempts to explain it. The first of the books mentioned above belongs to the so-called class of "practical" technical literature, one of the characteristics of which generally is more or less shaky English and incomprehensible explanation. As examples we may quote from page 7. The first lesson opens with this statement: "The foundation principle

* This chapter is entitled "Hovering Flight;" but this is a misnomer, as hovering implies hanging over.

of the Westinghouse automatic air brake is compressed air equalized, reduced or increased on opposite sides of pistons. . . . A homely definition of compressed air is, free air *hammered into hard but elastic shape.*" On the second page of the first lesson, in explanation of the storage of compressed air, it is said: "It is necessary that we do not confound 'capacity' with 'cubical contents.' A freight car might have a capacity for 4,000 cub. ft. of hay, but if it were only half filled the cubical contents would only be 2,000, while the capacity would still remain." If the writer had looked in a dictionary he would have found that the geometrical meaning of "content" is "area, or quantity of space contained within certain limits," and in that sense has the same meaning as "capacity." We can say with equal propriety that the capacity of tank, or that its content, is so many cubic feet.

A number of what are called "key charts" are given in the book to explain the principles of the brake. These illustrate what a hold the symbolical or emblematical method of exposition has on minds unaccustomed to habits of sustained thought. To such people an emblem seems to act like a mental balancing pole to an unskillful acrobat on a tight rope. If you speak of eternity to such people it does not seem to convey any very definite impression, but if you symbolize it with a circle, and represent hope by an anchor and meekness by a lamb, they will construct a whole system of theology on those symbols for a creed, and it may be that to some extent their lives and conduct will be influenced thereby. Following this symbolical method, our author has devised these charts, in which he has used words as symbols with apparently a sort of cabalistic meaning which a person who understands what he is trying to explain can vaguely comprehend; but it is difficult to see how the charts can explain the construction or operation of the brake to a person entirely ignorant of it.

The explanations of the construction of the brake are very inadequate for the purpose, and the engravings are generally "process" work of a poor quality, often without letters of reference on them or other means of identifying the parts referred to in the text. We are never tired of quoting Huxley's observation that "a prerequisite in good exposition is the imagining of methods by which, beginning with conceptions they possess, there may be built up in their minds the conceptions they do not possess." The book under review is an illustration of his further remark that "of constructive imagination as displayed in this sphere, men at large appear to be almost devoid."

The best chapters in the book are those which describe the practical duties of "train preparation," and "instructions to engineers, trainmen and inspectors," and the "rules for testing brakes."

"Diseases of the Air-Brake System" might very appropriately be called the diagnosis of air brakes. The sub-title describes accurately the character of the book, which points out the causes of defects, their symptoms and cure. It describes in very clear language and in a direct way the parts liable to get out of order, what happens to them, and what should be done when this happening takes place. As an example, the opening of the book may be quoted, which is on pumps, and in which it is said:

"The disorders that arise in this pump (Westinghouse 8 in.) may be classed under two general heads:

"1. Trouble in the upper or steam cylinder.

"2. Trouble in the lower or air cylinder.

"The parts in the upper cylinder most liable to derangement are the main valve (7), reversing piston (23), reversing valve (16), reversing valve stem (17) and the reversing valve plate 18."

The numbers refer to corresponding numbers in an engraving, which is a reproduction from the Westinghouse catalogue, and designate the parts referred to in the text. The book all through is a model of clearness and conciseness. All the descriptions are direct and easily understood. There is no attempt made to describe the principles, construction or operation of the brake excepting so far as these are involved in the defects described. The engravings, with a very few exceptions, are excellent. Especial interest attaches to those in the appendix, which represent various diseased organs of the brake and abnormal deposits which have been found in the various intricate parts of the apparatus. The book can be highly commended, and should be in the hands of every person who operates or has the care of air brakes. A slight defect which may be noted is the absence of titles to some of the engravings, which would have made their significance plainer.

The author calls attention to the fact that the book contains illustrations of practically all the devices in common use, and of several different makes, old as well as new. The W. F. Hall Printing Company, of Chicago, are the publishers.

TRADE CATALOGUES.

Ludlow Coupler Company, Springfield, O., Manufacturers of the Ludlow Freight and Passenger Central Draft Automatic Couplers. 16 pp., 3 × 5 in.

The purpose of this is apparently to illustrate and describe the Ludlow coupler, which is shown by various engravings; but the publishers have not been very successful in explaining its construction so that a person without any knowledge of it can understand its peculiarities; but perhaps that was not the purpose in having it printed. It is well printed and the engravings are good.

Catalogue and Price List of Surveying Instruments and Drawing Materials, Architects' and Civil Engineers' Supplies. A. S. Aloe Company, St. Louis. 212 pp., 10 × 6½ in.

Twenty-one pages of this publication are devoted to drawing materials, 32 to engraving and surveying instruments, and 123 to drawing instruments and materials. The volume is copiously illustrated with engravings of varying degrees of goodness and badness, but generally they are very good. A draftsman who cannot find materials or instruments to suit him in the large assortment so invitingly described in this catalogue must be hard to please. A good index adds much to the value of this catalogue.

Bement & Co., Manufacturers of Feed-Pump Governors and Automatic Feed-Water Regulators, Chicago. 10 pp., 3½ × 6 in.

This very small publication is devoted to a description of the Campbell feed-pump governor, which, it is said, is not designed "to maintain automatically a uniform water level in the boiler," but "is an automatic throttle valve for boiler feed-pumps, and will cause the pump to run at a speed which will at all times supply the exact quantity of water required." A perspective view of the device, report of tests and directions for applying it are given.

Catalogue of 1894. The Tainter Company, Stroudsburg, Pa. 47 pp., 3½ × 5½ in.

The opening page of the Tainter Company's pamphlet is a "plea for a better appreciation of the grinding industry." This is succeeded by remarks about prices, values of machines, etc., then practical hints about emery wheels, the uses for which they are adapted, and a classification of them into coarse-hard, medium-hard, medium-soft, etc. Twenty different kinds of machines are then illustrated. These are followed by remarks about emery, emery oil stone, emery knife sharpeners, polishing paste, liquid polish, knife powders, aluminous paint, etc. The last page contains what we do not remember ever seeing in any other similar publication—that is, a bibliography of the publications of this company, which includes six different treatises, papers, and brochures of interest to persons who use emery grinding machinery, and to that still larger class who ought to use it.

New Pamphlet of High-Grade Horizontal and Vertical Steam Engines and Steel Boilers, Manufactured by James Leffel & Co., Springfield, O. 32 pp., 5 × 7¾ in.

The frontispiece of this pamphlet is a good wood engraving showing the works of this company. Perspective views of two stationary engines are then shown—one with a bed plate and the other without. These engines have the usual form of frame now generally used, but center cranks—that is, they have crank-shafts which extend both ways from the crank, with a pulley on one end and a fly-wheel, which is also a pulley, on the other end. The frame has two pedestals on each side of the crank, so that the engine is self-contained and is balanced, although the method of balancing is not shown in the engravings.

The arrangement of steam-chest and valve gear is a little peculiar. It should be said that the engines which are represented all have ordinary slide valves. The steam-chests, instead of being on top or on the side of the cylinders, are placed diagonally between those two positions with the valve face inclined. The valve stem is then connected with the eccentric direct by a rod which is inclined, the stem being horizontal. This will probably strike some designers as a kind of mechanical discord, although, as the valve stem is provided with a strong guide, it is hard to see why an eccentric-rod will not work as well in such a position as a connecting-rod does.

Several perspective views are also given of what the manufacturers call their "self-contained, return tubular boiler," which they also say is known as the Cornish return tubular boilers, and are similar to those now generally used on ocean steamers. The outside shell of these is a plain cylinder with

a cylindrical fire-box inside and a smoke-box at one end, and an uptake at the other. The products of combustion pass from the fire-box to the smoke-box, and then through small flues above the fire-box to the uptake and up the chimney. The smoke-box door—and what a locomotive engineer would call its front, but which a stationary man would call the back—is lined with fire brick, so as to prevent the radiation of heat from the products of combustion while they are passing from the fire-box to the tubes.

There are also illustrations of a horizontal engine and boilers combined and detached, a portable engine, and of upright engines and boilers which this company manufactures.

The engravings are good, but have hardly had justice done them in printing.

BOOKS RECEIVED.

SANTO DOMINGO. Bulletin No. 52 of the Bureau of the American Republics. 202 pp., 6 × 8½ in., with map.

WHITE'S REFERENCE BOOK OF RAILROAD SECURITIES. Compiled from Official Sources. New York: White & Kemble, 62 William Street; London, E. C.: Frederick C. Mathieson & Sons. 496 pp., 4¾ × 6¼ in.

WATER OR HYDRAULIC MOTORS. By Philip R. Björling, Author of "Practical Hand-Book of Pump Construction." London E. C.: E. & F. N. Spon; New York: Spon & Chamberlain. 287 pp., 4¾ × 7 in.

REPORT OF THE PROCEEDINGS OF THE TWENTY-SEVENTH ANNUAL CONVENTION OF THE AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION. Held at Saratoga Springs, N. Y., July 18, 19 and 20, 1894. 310 pp., 6 × 9 in.

TEXT-BOOK ON ROADS AND PAVEMENTS. By Fred. P. Spalding, Assistant Professor of Civil Engineering in Cornell University; Member American Society of Civil Engineers. New York: John Wiley & Sons. 213 pp., 5 × 7¼ in.

NEW ROADS AND ROAD LAWS IN THE UNITED STATES. By General Roy Stone, Vice-President National League for Good Roads, and U. S. Special Agent and Engineer for Road Engineering, Department of Agriculture. New York: D. Van Nostrand Company. 166 pp., 7¼ × 5 in.

TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS. Vol. XXII, 795 pp., and Vol. XXIII, 685 pp., being Parts I and II of the Proceedings, Papers and Discussions of the Chicago Meeting of 1893, Constituting Divisions C and D of the International Engineering Congress.

MANUAL OF THE RAILROADS OF THE UNITED STATES FOR 1894. Showing their route and mileage; stocks, bonds, debt, cost, traffic, earnings, expenses and dividends; their organizations, directors, officers, etc.; with an appendix containing a full analysis of the debts of the United States, the several States and the chief counties, municipalities, etc., of the country. Also statements of street railway and traction companies, miscellaneous corporations, etc. New York: H. V. & H. W. Poor, 44 Broad Street. 1630 pp., 8¾ × 5¾ in.

TESTING GRAPHITE.

To the Editor of THE AMERICAN ENGINEER AND RAILROAD JOURNAL:

Your note to our letter published in THE AMERICAN ENGINEER for June is appreciated, and in order to supply the missing link we will simply say that the easiest way to determine the purity of plumbago is to blast it by means of a blowpipe, or to burn out the impurities by means of nitric or sulphuric acids.

Graphite, as you know, is one of the forms of carbon, of which the diamond is its twin brother. When you burn the diamond it all passes off in carbonic acid gas and nothing remains. In burning graphite, if the graphite is quite pure—say 90 per cent. pure—then there will only remain 10 per cent. impurity, and it usually matters little what that impurity is; it is sufficient to know that you had 90 per cent. of carbon or graphite.

We omitted this in our previous letter for the reason that we supposed that such of your readers who had more or less knowledge of chemistry would readily know how to determine the purity of graphite by laboratory tests, and we have no doubt that many of your readers do know quite as well as we ourselves. Yours respectfully,

JOSEPH DIXON CRUCIBLE COMPANY.

LOCOMOTIVE HISTORY.

WE are indebted to the indefatigable investigator into the history of locomotives, Mr. Clement E. Stretton, of Leicester, England, for the following contributions of interesting data relating to the early history of locomotives in this country. As we have taken occasion to remark before, few people at present are aware how large the number of locomotives was that were imported into this country from England in the early days of our railroads.

Editor AMERICAN ENGINEER AND RAILROAD JOURNAL:

I have read with great interest the list of locomotives given in your issue for March, p. 133, and have also compared the same with lists, details and drawings in my possession. However, I find the names of several engines which were sent from England to America are not mentioned in the list, p. 133; for instance, R. Stephenson & Co., in 1832, sent an engine named *Maryland* to the Newcastle & Frenchtown Railroad. In 1831 that firm sent an engine, *John Bull*, to the Hudson & Mohawk Road. In 1831 Stephenson & Co. sent the *Stevens* to New York. Another R. Stephenson engine was named *Whistler*. It appears to have been constructed to the order of Captain Whistler.

In 1833 R. Stephenson & Co. built the well-known engine *Edgefield* for the South Carolina Railroad Company. Another engine built by R. Stephenson & Co. seems to have been named the *Boston*, and to have been built to the order of Mr. Jackson. Altogether I have before me the proof that the firm of R. Stephenson & Co. sent no less than 31 locomotive engines to the United States between the years 1828 and 1837.

In the list on p. 133 I observe that in some cases R. Stephenson & Co. are put down as Manchester, and in others Liverpool. Both are wrong, as the works have always been at Newcastle-on-Tyne.

The works of Tayleur & Co. were near Warrington, not Liverpool, as given in one case. I am at a loss to understand the word "Swartwout" as intended for an English firm. The Camden & Amboy No. 1 was, of course, the *John Bull* shown at the Chicago Exhibition, and built by Stephenson in 1831.

D. & I. Burr & Co., given in the list, is evidently a mistake. My information leads me to believe that this was only a firm of agents who acted for the locomotive builders, Messrs. Mather, Dixon & Co., of England.

The makers of the two last engines on the list are given as John Bull; they are, however, two engines built by Stephenson. The Petersburgh Railroad had three engines from Mather, Dixon & Co., one the *New York*, another *Philadelphia*, the third *Petersburgh*. That line also had several engines from Braithwaite & Co. I trust these few details may assist those of your readers who may wish to further investigate the subject.

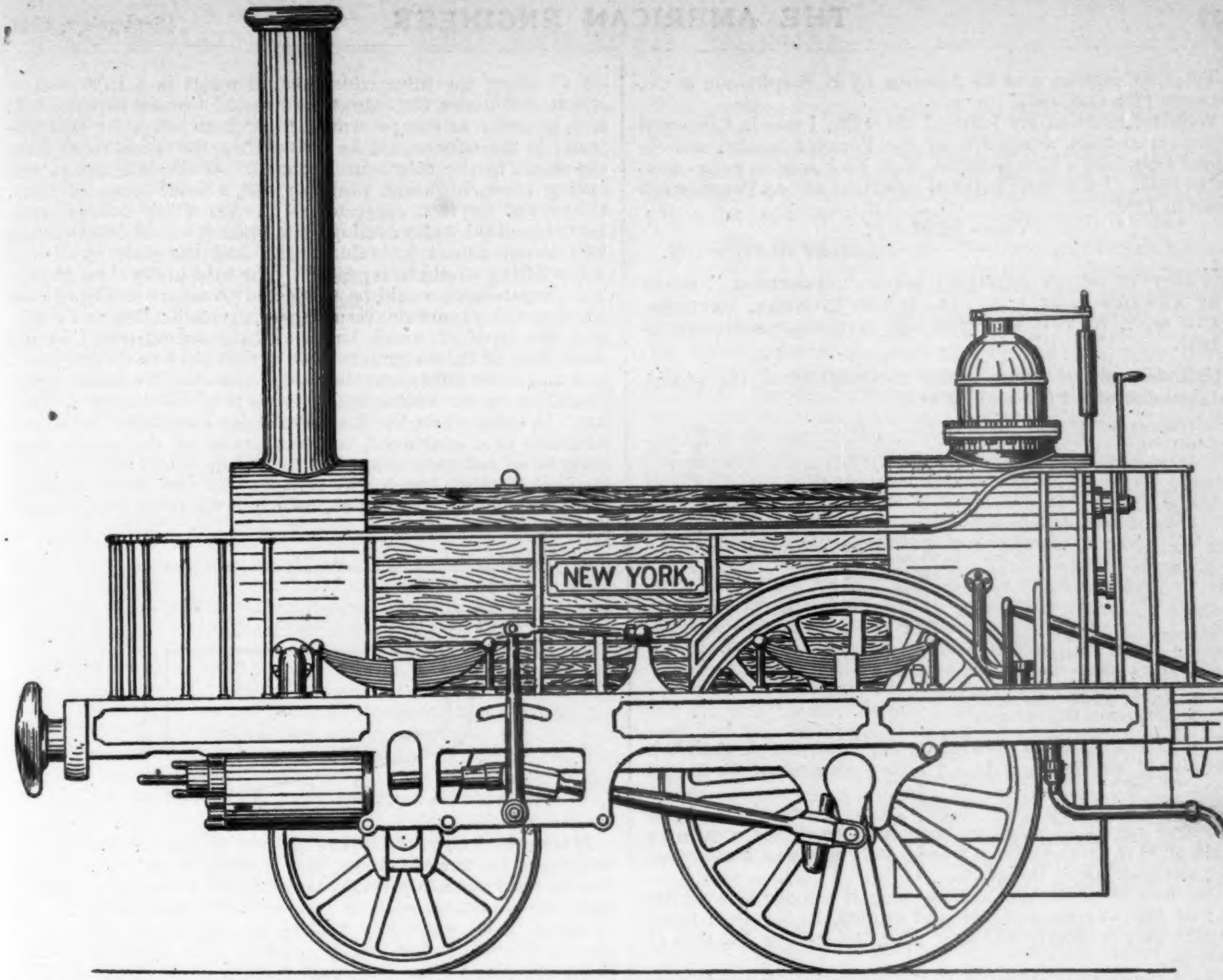
CLEMENT E. STRETTON, C.E.

SAXE COBURG HOUSE, LEICESTER, ENGLAND.

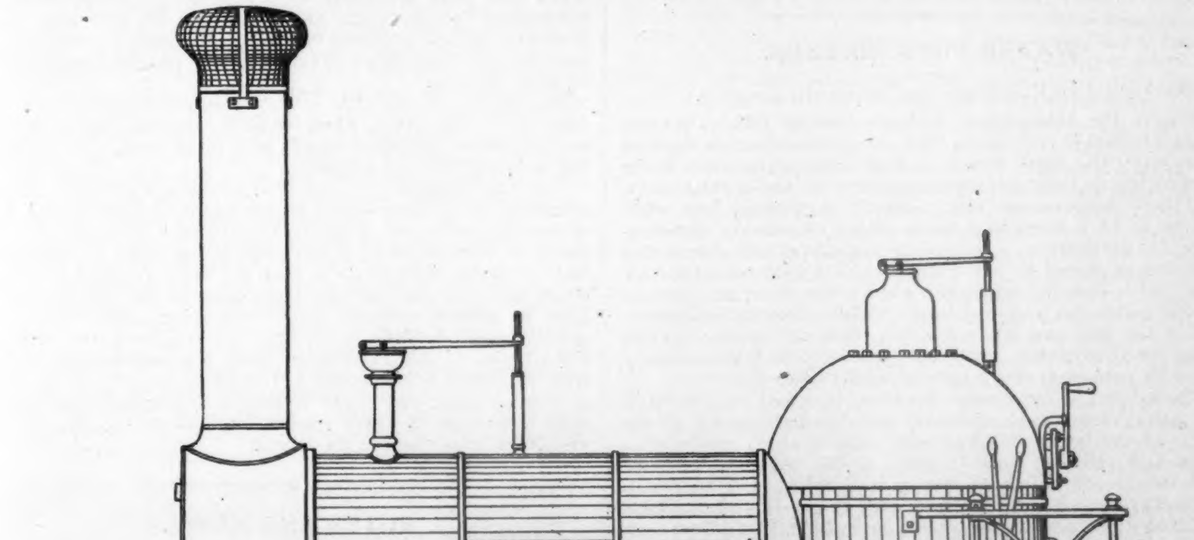
On p. 132 of THE AMERICAN ENGINEER reference is made to the list given in Wood's book of 1838. If you refer to that list you will find some blanks which I now fill up for your information.

Private makers' numbers, see Wood, 1838.

1828	America	12	Delaware & Hudson Canal.
1828	Whistler	17	" " " "
1828	Delaware	23	Newcastle & Frenchtown.
1828	Boston	27	" " "
1828	Maryland	28	" " "
1828	Pennsylvania	(?)	" " "
1833	"	42	For Saratoga—Bogie Engine.
1833	(?)	52	Not known.
1833	Edgefield	54	South Carolina R.R.
1833	"	60	Mohawk & Hudson.
1833	"	61	" " "
1833	"	75	" " " Bogie.
1834	W. Aiken	87	Columbia R.R.
1834	Howe	103	South Carolina.
1834	"	104	Pennsylvania R.R.
1834	"	105	" "
1834	"	106	Columbia R.R.
1835	Kentucky	110	Not certain for which road.
1835	John Bull	112	Not certain for which road.
1835	Atlantic	113	Not certain for which road.
1835	Sumter	114	South Carolina—Bogie Engine.
1835	Marion	115	" " " "
1836	Ohio	116	" " " "
1836	"	117	Not known which road.
1836	"	120	" " " "
1836	Wayne	125	" " " "
1836	Nash	126	" " " "
1836	"	129	Lexington.
1836	"	139	"
1837	"	151	Baltimore & Susquehanna.
1837	"	152	" " "



LOCOMOTIVE "NEW YORK." BUILT IN 1834 FOR THE PETERSBURGH RAILROAD, BY MATHER, DIXON & CO.



LOCOMOTIVE "LIVERPOOL." BUILT IN 1831 FOR THE PETERSBURGH RAILROAD, BY EDWARD BURY & CO

Total, 31 engines sent to America by R. Stephenson & Co. between 1828 and 1837.

With reference to my letter of the 13th, I was in Liverpool yesterday and saw a member of the Forester family, and obtained from him a blue print of *New York* sent to your country in 1834. I also send print of *Liverpool* sent to Petersburgh Road in 1831.

Yours faithfully,
CLEMENT E. STRETTON.

DESCRIPTION OF LOCOMOTIVE ENGINE "LIVERPOOL," BUILT BY EDWARD BURY & CO., CLARENCE FOUNDRY, ENGLAND, AND SENT TO THE PETERSBURGH RAILROAD COMPANY IN 1831.

Cylinders placed inside under the smoke-box, the piston-rods passing under the leading axle.

Diameter of cylinders		9"
Stroke	1'	6"
Diameter of leading-wheels	4'	6"
" " driving-wheels	4'	6"
Wheels coupled by rods	4'	
Wheel-base	5'	
Front of buffer-beam to smoke-box	1'	7"
" " " " back of smoke box	3'	5"
" " " " leading-wheel center	4'	6"
" " " " driving-wheel center	9'	6"
" " " " front of firebox casing	10'	8"
" " " " back " " "	14'	2"
" " " " " " frame	15'	5"
Boiler barrel, diameter	3'	
" " length	6'	9"
Length of dome casing	4'	
" " fire-box casing	3'	6"
Height of frame from rails	3'	
Rails to center line of boiler	4'	8"

The *Liverpool*, when working on the Petersburgh Railroad, weighed 11,200 lbs., and had a boiler pressure of 50 lbs. of steam.

In November, 1833, this engine drew 15 wagons and one passenger car at 15 miles an hour on a level, and went up a grade of 30 ft. to the mile at from 8 to 10 miles an hour, stopping and starting on the grade.

The weight of freight and passengers carried was 83,620 lbs.; of the wagons and car and engine, 67,500 lbs.; total, 151,120 lbs., or nearly 62½ tons of 2,240 lbs., or 75½ tons of 2,000 lbs.

The above is an exact copy of the dimensions found in possession of the Bury family.

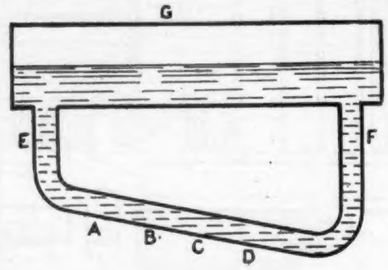
WATER-TUBE BOILERS.

Editor AMERICAN ENGINEER AND RAILROAD JOURNAL:

Despite the antagonistic feelings that at present prevail against boilers of this type, they are becoming more popular every day; the chief causes of their disapproval have so far been owing to their improper construction and management, but these features are being steadily overcome, and what proves to be a stumbling-block to-day becomes a stepping-stone for the morrow. Numerous misleading and absurd theories are advanced to cover up the deficiencies of each new type that is brought before the public, but these are soon exploded under the practical tests to which they are subjected, and in due time pass into obscurity, while the boiler struggles along for an existence, but finally has to yield to an untimely death by corrosion, and is hurried to the scrap-pile.

The subject of circulation has been discussed and reviewed by many theoretical engineers, and the movements of the water in the boiler followed with mathematical precision in space and velocity, until it seems to the would-be inventor that the theory advanced was a sure thing, and forthwith attempts to put it into practical operation. Having built his boiler on the lines of theoretical circulation, he finds on testing that he is as far from the desired goal, as far as practicability is concerned, as when he started. These expensive experiments generally result in disgust and condemnation of all water-tube boilers, and a return to the old familiar shell pattern with all its faults.

In order to produce steam economically it would be necessary to reverse the process as found in the tubular boiler—viz., to cut up the water spaces (as water is a poor conductor of heat) and enlarge the fire spaces, for by dividing the flames and gases combustion ceases and a waste of fuel is the result. This feature of cutting up the water spaces has been overdone in most of the tubulous boilers now on the market. If we take a tube, say, 16 ft. long and 3 in. diameter, and connect it to a steam drum, as shown in the cut, by applying intense heat (as in forced firing) along the parts *a b c d*, the steam generated at *a* would not have time to reach the steam space before the steam at *b* would have overtaken it, and so on all along the tube, which would result in a tube full of steam, and under the intense fire would become superheated, and in order to escape would force both ways, so that the water in the tube would be driven into the steam space until the steam in the tube was liberated. While this action was taking place, although probably but a brief space of time, the part of the tube subjected to the fire would become overheated, and the water coming back upon it would be converted into steam almost instantaneously, and the same action of water lifting would be repeated. The tube under these changing temperatures would be subjected to severe strains of contraction and expansion, resulting in crystallization and corrosion, the proof of which has been fully demonstrated by the short lives of the water tube boilers that have come and gone, and unless the tubes are shortened, allowing the steam quick liberation to the steam space, these troubles may be looked for. In cases where the design calls for long tubes in its construction or a continued, tortuous travel of the steam, they must be of sufficient diameter, so that the water may take up the heat applied, but it will be seen that very little economy would be gained in doing so, owing to the large water spaces and forced circulation.



It is a well-known fact that as soon as steam is formed the sediments are thrown down, and if there is no water in the tube to hold them in solution they adhere to the tube, and by rapid accumulation scale is formed. On examination it will be found in all water-tube boilers that the deposit of scale is greater where the most heat is applied. The recent discussion at the meeting of the American Society of Mechanical Engineers brought to light a great many defects in this type of boiler that have heretofore been kept silent, or their defects covered up by nonsensical theories which are generally swallowed by the less practical purchaser, to whom it often proves an expensive dose when it comes to the practical application of these theories.

The safety of this type is a very important feature to be considered in its favor, when we look over the long list of disastrous boiler explosions which take place every year, resulting in loss of life and property.

The requirements of a practical working water-tube boiler, according to my idea, would be one that shall have short tubes so arranged as to give a natural circulation; quick delivery of steam, unimpeded in its ascent to the steam space; a sufficient body of water at all times to keep the tubes supplied; a large steam space, as this is of vital importance to this type of boiler; light in weight, covering small floor space; and, above all, one that shall be easy to repair when repairs are necessary. For a boiler of this description there is a vast field to be covered, and such a one would sweep away the objections that at present exist, and prove beyond a doubt that the water-tube boilers are in every respect superior to the shell type. Who will bring them to the front? C. T. C.

NOTES AND NEWS.

Railway Accidents in Great Britain.—The government Board of Trade has issued a report giving the number of employés killed and injured during the years 1870, 1873, 1877, 1880 and thereafter to 1892. The smallest number of deaths and injuries occurred in 1870, when 115 deaths and 129 injuries were reported. The last year with which the report deals—that is, 1892—there were 534 killed and 2,215 injured. The proportion of killed to employed was 1 in 714, and of injured to employed 1 in 120.

Gun Work Rejected.—As a result of the recent armor-plate exposures the officers appointed to inspect material for the Navy have been doubly alert, and it now transpires that 29 sets of gun forgings made by the Midvale Steel Company have been rejected. In the forgings the inspectors at the Washington Navy Yard detected a number of fine hair cracks, all in 8-in.

gun work. In many cases the cracks were so fine that the use of a glass was necessary to detect them. The matter was reported to the Ordnance Bureau, and Captain Sampson determined to reject the entire lot, holding that with the tremendous pressure to which the guns are subjected it would be dangerous to put them in use. The company appealed from the decision, but the Board appointed to reinspect the work found that while the hair cracks did not extend for more than an inch or two, in some instances it was discovered by cutting into the material that frequently where one crack would end another would begin. The conclusion reached, therefore, was that the material, for some reason not known to the company or to the experts, was not of the high quality which is required by the contract, and which the company has hitherto turned out. The company will be required to furnish 29 extra sets of forgings, amounting in value to about $50,000.

Compressed Air in a Coal Mine.—In the great Nottingham Colliery of the Lehigh & Wilkesbarre Coal Company at Plymouth, Pa., compressed air is practically utilized for operating the drainage pumps. The Nottingham Colliery is located in the west side of the north branch of the Susquehanna River. The mine is operated by a shaft 365 ft. deep from the surface to the bottom landing, and the workings are extended deeper into the basin by underground slopes of comparatively light pitch. A portion of the workings extend under the river, and this fact, in connection with the location of the major portion of the workings under the low ground of the Wyoming Valley, make necessary the employment of an extensive pumping plant, so as to provide for extraordinary drainage during the wet seasons. Until a few months ago steam was used, but the low pressures available at the pumps, together with the expense of maintaining a safe roof in the passageways through which the steam pipe ran, the liability to accident and interference with the ventilating currents in case the steam pipe was broken, together with a number of other objections to steam, induced the management of the company to adopt compressed air, which fully meets the requirements of the work and the expectations of the company.—*Manufacturers' Gazette.*

Building on Quicksands.—The well-known German engineer, Neukirch, in a paper on making foundations in quicksand, urges that the sand on which the foundation is to rest be converted into solid concrete by blowing into it, by air pressure, powdered dry hydraulic cement, using for this purpose a $1\frac{1}{2}$-in. pipe drawn to a point at its lower end and having three or more $\frac{3}{8}$-in. holes. In practice this pipe is joined at its upper end by a rubber tube to an injector, which is connected to a source of compressed air and is fed with dry cement, the sinking of the pipe to the depth required being facilitated by blowing air through it during its descent and setting it in motion, a depth reaching to 19 ft. being thus quickly accomplished. After this the cement is fed in and carried into the sand by the air, which, being forced up through the former, insures a thorough mixture with the cement, and the tube is then slowly withdrawn, the supply of cement being continued until it reaches the surface, the concrete formed in this way taking several weeks to harden and requiring some months to attain its full strength. Further, the whole area to be treated is divided into a number of small areas of about 1 sq. ft. each, and, the tube being sunk successively and operated on each of the squares, it is found that the mixture of the sand and cement produced occupies less space than did the sand alone before the operation. This method of operation has been resorted to successfully in coffer-dam construction and sewer work where such had to be laid in quicksand.

Pensions on the Prussian State Railway.—The pensions and indemnities against accidents which are paid by the management of the Prussian State Railway, as provided in law, are comprised in the two following cases:

1. In case of accident resulting in an incapacity to work, the victim is provided with the necessary medicines and medical attendance free of charge, and insurance equivalent to two-thirds of his usual wages is paid to him. During the first three weeks this expense is charged to the sick fund, which is supported by a tax of 3 per cent. of the wages of the men, of which 1 per cent. is paid by the men themselves and the remainder by the company. If the incapacity to work is only partial, the pension is reduced so as to correspond with what the man can earn by his own labor.

2. In case of death the widow of the employé is allowed a pension equal to 20 per cent. of the wages of her husband, and to each of the children until the age of 15 years is reached, a pension amounting to 15 per cent. is given, provided the mother still lives, and 20 per cent. if she is not living. Finally, parents also receive an income equal to 20 per cent. of the workman in case he was their only support. Taken all in all, these pensions cannot exceed 60 per cent. of the wages of the workman.

In 1892 the number of workmen and employés on the Prussian State railways, who paid their premiums in order to take advantage of this law, was 188,958, about equally divided between the operative department and workmen in shops.

Handling Great Weights.—With monster bullets has come the necessity for handling great weights. The engineer officers in charge of the coast defense guns have been confronted with the problem of bringing huge projectiles from the magazine to the breech of the big guns. With shells weighing 1,000 lbs. apiece, such as the projectiles for the 12-in. rifles, the employment of mechanical power for their speedy handling is obvious. Special facilities also had to be resorted to in the transportation of the powder. Colonel Gillespie, in charge of the coast defense at New York Harbor, is carrying out a plan for the necessary conveniences at the gun-lift battery in New York Harbor, where are mounted two 12 in. high-power breech-loading rifled guns. A 36-in. gauge track runs from the wharf through the entrance of the battery to a transverse gallery connecting the magazine passageways, where a turntable is placed, from which a track leads, right and left, to points opposite the entrance to the magazine passage. There are other connections and another turntable, so that by the system the ammunition loaded upon flat cars from a lighter at the wharf may be delivered at the entrance to the magazine passages. There it will be transferred to the ammunition car by an overhead trolley and hoist of 2,000 lbs. capacity. The transfer completed, the car can be run directly into the magazines. The latter, designed for the storage of shells, are provided with an overhead traveling bridge, trolley and hoist, so that one man can handle a load of 2,000 lbs. at any point of the magazine. The combined ammunition carriage and loading tray, forming part of the gun lift, can, by the same system, be run from its place over the ram of the ammunition hoist into the magazines, receive its powder and projectiles, and have them conveyed to their final position in the gun entirely by mechanical power.—*New York Times.*

Town Refuse as Fuel.—In a recent issue of the *Popular Science Monthly* a description of a Livet furnace which has been set up in Halifax, England, for the purpose of burning town refuse and is successfully working, was given. This furnace appears to depend upon the peculiar construction of its flues, which are so built as to utilize the effect of the decreasing volume of the gases of combustion traveling toward the chimney, thus promoting a high velocity to the air passing through the furnace bars and producing rapid combustion with intense heat. At the same time, the effect of this peculiarity of construction is to cause the gases themselves to move slowly through the flues, so that they may part with their useful heat before escaping into the atmosphere. The force of the draft at the furnace is such that a high and constant temperature is obtained and efficiency of combustion insured, while all unpleasant odors inherent in town garbage are destroyed. As an example of the heat economy effected, it is said that whereas in previous generators the best results ever obtained have been $\frac{3}{4}$ lb. of water evaporated on the combusion of 1 lb. of refuse, in the Livet generator over 8 lbs. of water are evaporated into steam for every pound of refuse consumed, in spite of the fact that it is frequently known to contain 20 per cent. of moisture. The temperature of the gases just before entering the chimney is stated to be from 300° to 400° F. lower than hitherto obtained. The progression of the gases is partially arrested at both ends of each flue for the purpose of permitting them to deposit the contained light dust in suitable expansion chambers or pits which can be cleaned out when desirable. This arrangement serves to overcome the objectionable dust, which in ordinary "destructors" tends to choke the flues and impregnate the air of the surrounding districts.

Canal Boat Resistance.—The resistance of canal boats to traction has been investigated for the Ministry of Public Works of France by M. de Mas, the account of the experiments being given in a two-volume report issued recently by the Ministry. It was found that at a speed of 3.28 ft. a second the resistance of the 70 odd types of barges ranged anywhere from 3 to 8 lbs. per square foot of immersed section. If the resistance at a speed of 5 ft. a second with a draft of 3.28 ft. (1 meter) is called unity, the resistance with a depth of 4.27 ft. (1.3 meters) becomes 1.13, and with a draft of 5.25 ft. (1.6 meters) becomes 1 27—that is to say, the resistance does increase with the displacement of the boat, but more slowly. Another fact found out was that the resistance may be much reduced by using smooth surfaces below the water-line, the total resistance of a wooden barge being diminished from 782 lbs. to 551 lbs. by covering the sides with oilcloth. The length of the boat was found to have little influence on the traction

when the speed was 5 ft. or more a second, but the form of bow and stern was shown to be important, a spoon shaped bow giving the best results. It is probable that similar tests of resistances will necessarily be made to boats on the American canals as soon as electrical traction has obtained a firm hold, as it undoubtedly will. The present form of canal boat bow is one that is anything but well adapted to a clean and easy movement through the water. There are a few vessels on the Great Lakes which are built in nearly this form, and when they are being forced through the water at a speed of from 8 to 9 miles an hour the wave which banks up in front of them is like the swell following such fast steamers as the *Sandy Hook* and *Monmouth*, running in New York Harbor, with the difference that instead of a smooth, flowing curve, it rises in front like a solid resisting wall. The same may be seen in front of the bows of many steam-propelled canal boats. As long as the mule was the motive power of the canal, and the owner and captain ignorant of the loss by resistance and the speed, there was no probability of any investigation being made; but as soon as large corporations take the matter of propulsion in hand, the labor-saving spirit will prevail, and the most economical forms be adopted as a result.

New Small Arm for the Navy.—The great powers of Europe are almost as deeply interested as is the United States in the competitive tests of small arms begun at Newport Naval Torpedo Station on August 1, where the final step is being taken toward equipping the marines and bluejackets of this country with the most destructive weapon in the world. The small arm at present used in the navy is the familiar .45 in. caliber, which, with the regulation black powder, gives an effective range of 1,200 yds., only 55 rounds being carried per man. With the high-velocity-producing smokeless powder, these guns are rapidly becoming obsolete, and all modern nations have adopted new weapons with smaller calibers. Italy, Roumania and Holland have chosen 6.5 millimeters; Spain and Chili, 7 millimeters; the new United States Army caliber is .30 in.; the famous Lebel of the French is 8 millimeters or .315 in.; the Mannlicher of Germany is 6.5 millimeters; and the ordnance sharps of the United States Navy, after careful consideration, have adopted a caliber of 6 millimeters, or .256 in., the smallest bore used in warfare, being but slightly greater than the familiar .22 in. caliber of the small boy's first pistol or the "cat" rifle.

However, the cartridge the Navy will use in the new gun is totally different from the popular bullet cap. Its projectile looks like an inch and a half of heavy telegraph wire, and the explosive chamber of the cartridge widens out like a champagne bottle. The bullet is nickel steel, coated with nickel, weighing 135 grains; the explosive is 40 grains of rifleite—the highest power of smokeless explosive—the effective or killing range is 2,000 yds., and each man can carry 150 rounds. The United States arsenals have already manufactured a large number of the new barrels, which are but 30-in. long, and the long projectiles from them have been driven through 30 in. of solid pine. Thorough tests have demonstrated the wisdom of adopting the smaller caliber; and the only thing that now remains to provide American bluejackets with the most terrible life destroyers is a breech mechanism enabling the accurate discharge of the greatest number of projectiles in the least time.

Naval officials have the highest confidence in the ability of American ingenuity to supply this desideratum, and with this in view last March Secretary Herbert called upon inventors for a breech mechanism, offering to furnish the new barrels for experimental purposes, and naming August 1 as the date upon which completed guns should be submitted, and tests under a competent Naval Board should commence at Newport. The Government is now ready to begin these tests. It has furnished 27 barrels, many of them to famous gun-makers, and much curiosity exists as to the contrivances submitted. The first order for the new guns—all barrels being made by the Government and the weapon to be finished by the successful inventor—will probably amount to 15,000 arms. It is confidently expected that some radical improvements in small-arm practice will be developed, and little or no doubt is expressed that the United States will secure something superior to anything in use in Europe, if indeed an advance is not made which will astonish the world as much as early great American inventions.

The tests at Newport are exceptionally severe—safety, general action, defective ammunition, excessive charges, rapidity, accuracy, and ability to stand dust and rust entering into consideration. The endurance test will be 500 continuous rounds without cleaning, and the facility with which the breech mechanism and magazine system can be completely taken apart and put together will be noted.

It is understood that upon the result of these trials will depend whether France will abandon the wonderful Lebel arm, with which she has gone to such enormous expense in equipping her troops, and follow the lead of the United States in adopting the smaller caliber and a superior magazine arm. The tests of machine guns which have been going on at the Washington Ordnance Factory and Indian Head Proving Grounds were undertaken with the purpose of selecting the best machine gun mechanism for the newly adopted barrel.—*New York Sun.*

Freight Locomotives in Germany and England.—During the past year some new freight locomotives have been built in Germany and England which are especially interesting in that they indicate the complete deviation from the ideas which have prevailed for a long time in these two countries regarding engines of these types. They are engines of eight wheels coupled. We mention first the engines built at the shops of the London & Northwestern Railway, at Crewe, for coal trains running over this line, and which were constructed in accordance with the designs of Mr. F. W. Webb. The axles, which are four in number, are all coupled together, the last one being back of the fire-box, after the English fashion. This fact, then, with the diameter of the wheels, which is 5 ft. 6 in., causes the distance between the front and back axle to be considerable, amounting to 16 ft. 4 in. the front and back axle having a side play of $\frac{1}{2}$ in. There are three cylinders side by side and all driving the same axle, which is the second one; the central cylinder, which is the low-pressure one, has a diameter of 2 ft. 6 in.; the outside high pressure is 1 ft. 3 in. in diameter, which gives a ratio of volume of 2 to 1. The stroke is 2 ft. for the three cylinders; but the valves of the outside cylinders are operated by the link, while the inside is driven by an eccentric giving a fixed cut-off the same as used by Mr. Webb in his later passenger engines. The boiler works under a pressure of 180 lbs to the square inch; the grate has an area of 20.34 sq. ft. and 210 tubes of $1\frac{3}{4}$ in. diameter, with the length of 13 ft. 4 in. The heating surface of the fire-box is 114.66 ft., that of the tubes 1,372.50 ft., making a total heating surface of 1,487.16 ft. The distribution of the weight on the four axles is somewhat unequal, as we would be led to expect from the general arrangements. The front axle carries 28,000 lbs.; the second, 32,200 lbs.; the third, 28,450, and the last, 21,600 lbs., giving the engine a total weight in working order of about 50 tons. The tractive power of the compound engine can be estimated by taking .50 for the small cylinders, which causes the coefficient of reduction to disappear, since there are two of them giving the formula $p \frac{d^2 l}{D} = 14{,}727$, corresponding to about .15 of the total weight. This coefficient of adhesion is somewhat low for a locomotive with tender, although the English papers which give reports of this engine do not show that any provision has been made for admitting live steam into the large cylinders so as to temporarily increase the tractive power. It is hardly necessary to say that in this model, although there are three cylinders, there is nothing to suggest the type of passenger engines designed by Mr. Webb, in which the cylinders act on different axles in such a way as to get a better distribution of their power. They rather resemble the three-cylinder engines tested by Struve, in Russia, in 1881. It is said that these engines give good results, although no comparative tests as yet have been made between them and engines of the same type, but having only two cylinders, which have been previously built by Mr. Webb for coal service on the London & Northwestern Railway. The Germans have only used engines with six wheels coupled at rare intervals up to the present time. The Baden roads had some built about 20 years ago with eight wheels coupled. Würtemberg roads have had some with ten wheels coupled and flexible connections on the Klose system built within recent years. The Hanoverian Society, formerly the firm of G. Egerstoff, built a locomotive last year which was the 2,500th sent out from this establishment, and which seems to have been built after the American model, as it is, in reality, a consolidation engine—that is to say, it had eight wheels coupled with a pony truck ahead of the cylinders. The coupled wheels were 4 ft. 2 in. in diameter, and the truck wheels 3 ft. 4 in.; the total coupled wheel base 19 ft. 7 in. The steam pressure is 165 lbs. to the square inch; the grate area is 24.75 sq. ft. and the total heating surface is 1,550 sq. ft., with a diameter for the shell of the boiler of 3 ft. 4 in. The fire-box is beneath the back axle, and there is an extension smoke-box. There are two cylinders: one with a high pressure with a diameter of 1 ft. 9 in., and the other low pressure with a diameter of 2 ft. $5\frac{1}{2}$ in., located outside the frames and slightly inclined to the horizontal; the stroke is 2 ft. 1 in. There is a single guide to carry the cross-head, and this is placed above as usual. The valves are inside and controlled

by Allen links. One peculiarity is that this engine is arranged to work at will, either as a compound or simple engine with independent admission and exhaust for the two cylinders. For this purpose it is provided with a non-automatic arrangement after our system, but modified by Mr. von Borries: The engine has a steam brake; it has an air screen somewhat extended out toward the front to accommodate the engineer. The weight is 51 tons empty and 58 tons in working order, of which 52 tons are upon the driving-wheels; with the tender filled the total weight is 90 tons; the tractive power of the compound in running order is 18,740 lbs., when working as a simple engine it would be somewhat more than this. Taking 3.6 sq. ft. of heating surface per H.P., the tractive effort which can be obtained at a speed of 9 miles per hour is 17,410 lbs. The pull corresponding to the adhesion at .15 is 17,190 lbs. The engine is intended for running over the tracks with an undulating profile on the Prussian State Railway, while double heading with six-coupled wheels is now required. These engines were ordered by the management of the Hanoverian Railway; but the Right Bank of the Rhine Railway of Cologne have actually tried this articulated compound engine of two axles each, weighing about 56 tons; it has also been done by the State Railway of Baden. They have a little more adhesive weight with a little less total weight, a little more cylinder capacity with the same heating surface as the engines just described. They are very similar, with the exception of the independent tender, to the locomotives of the same system used on the Central Railway of Switzerland. There is, therefore, the means at hand of making an interesting comparison between two types of compound engines of the same power, one with two and the other with four cylinders.—*Revue Générale des Chemins de Fer.*

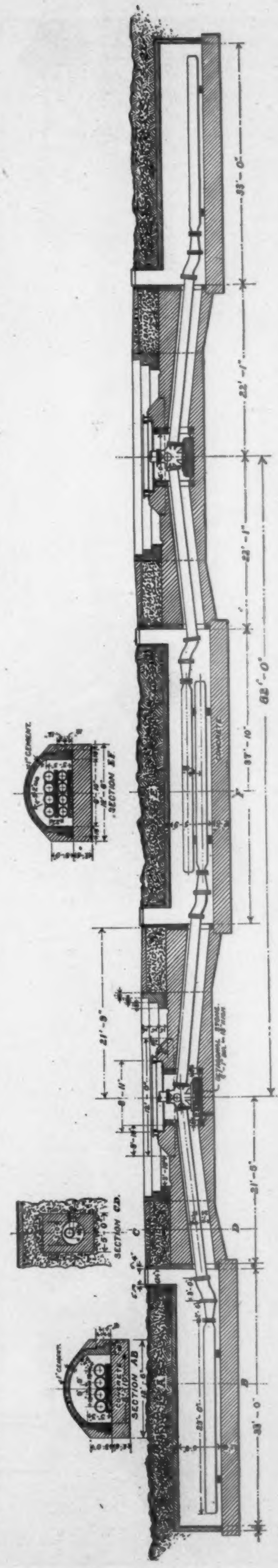
THE PNEUMATIC DYNAMITE GUNS.

Our readers are more or less familiar with the work that has been done and the experiments that have been made with the dynamite cruiser *Vesuvius*, as well as the fact that *El Cid*, afterward the *Nictheroy*, of the Brazilian Navy, was equipped with a pneumatic gun for firing a charge of dynamite. The work that has thus far been accomplished is of such a character as to fully demonstrate the practicability of the pneumatic dynamite gun, both for accuracy of aim and reliability of the explosion of the charge at the point of impact. In view of these conditions, the Pneumatic Torpedo & Construction Company, of 41 Wall Street, New York, are just completing a battery of three guns for the coast defense at Sandy Hook, N. J., and have the contract for another that is to be located at San Francisco, Cal.

The specifications for the Sandy Hook contract require that the company shall place a battery consisting of one 8-in. and two 15-in. guns, including all of the machinery necessary to fire and handle the same, including carriages and ammunition.

The length of the 8-in. gun is 70 calibers and that of the 15-in. 40 calibers. Our illustrations all refer to the larger gun. The plant includes a complement of boilers, air compressors, storage reservoirs and pumps that will give a capacity for a continuous fire of extreme range of 50 rounds for the first hour, comprising 20 rounds from the 8-in. gun and 30 rounds for the two 15-in. guns, and 30 rounds per hour thereafter. The boilers, which lie at the basis of the whole work, are of the ordinary horizontal return tubular type. They are four in number, each 5 ft. 6 in. in diameter, and 16 ft. long, with one hundred 3-in. tubes. These boilers are fed with both pumps and injectors, either of which is of sufficient capacity for regular working. At present a natural draft is used, with a separate stack for each boiler, but it is probable that after the parapet has been built in front of the guns that these stacks will be removed and a forced draft substituted, as the stacks could be readily shot away, thus seriously crippling the plant. Water is obtained from wells sunk in the sand just outside the building.

The compressors are in duplicate, each one being amply sufficient for the service of the gun as required by the contract. They are what is known as the three-stage compressor, or the reverse in their action to that of a triple-expansion steam engine. Each compressor has two sets of steam cylinders that are 16 in. in diameter, with a stroke of 22 in. One end of the piston-rod makes the usual connections to the crank-shaft, while the other extends back through two air cylinders that are placed tandem behind the steam cylinder. Next to the steam cylinder on each side there is one first stage air cylinder. These two cylinders are 14 in in diameter and are connected in parallel, delivering their air into an intercooler located between the first and second cylinders. After leaving the second cylinder the air passes through another intercooler

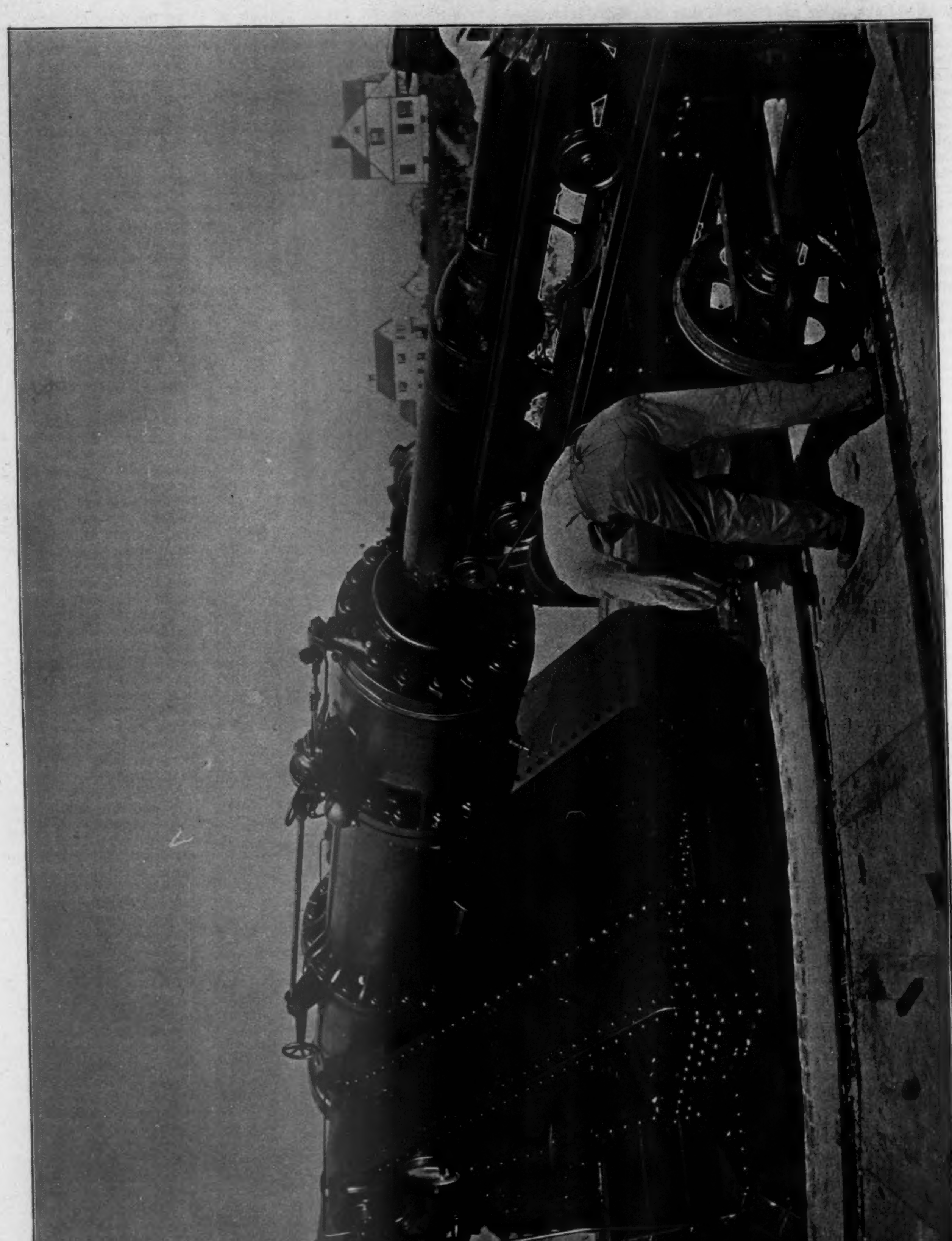


SECTION THROUGH SUBTERRANEAN FIRING RESERVOIRS FOR DYNAMITE GUNS AT SANDY HOOK, N. J.

to the third cylinder, wherein it is compressed to the final pressure, which ranges from 1,000 lbs. to 2,000 lbs. per square inch.

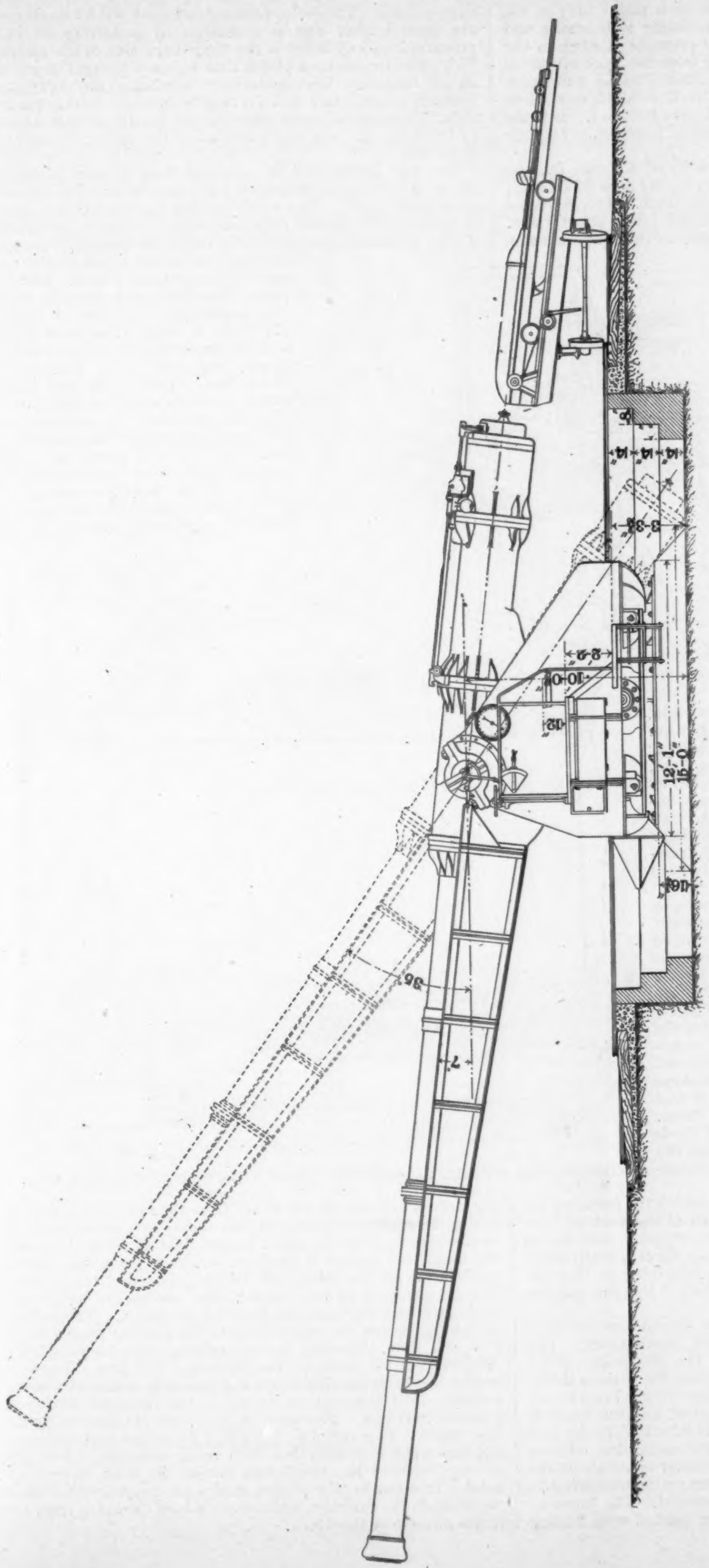
When the air leaves this cylinder it passes through an after cooler in order to reduce the heat to which the joints are exposed, thus bringing it down to average atmospheric temperatures. The diameters of the three compressing cylinders are 14 in., $8\frac{1}{2}$ in. and $4\frac{1}{4}$ in. respectively for the low, intermediate and high pressures. The air pressure as it leaves the first cylinder is 75 lbs., and 375 lbs. for the second. The compressor plant also includes two duplex pumps with steam cylinders 6 in. in diameter, and water cylinders $5\frac{3}{4}$ in. in diameter, with a common stroke of 6 in. These are used to circulate water through the coolers and water jackets of the cylinders. Finally, there is a 50 H P. high-speed engine driving a 38-kilo-watt dynamo at a speed of 850 revolutions per minute, and developing a 110-volt current. This current is used for the electric lights about the building and for driving the electric motors on the gun carriages. A slate switchboard in the engine-room contains an ammeter, voltmeter and switches for connecting to the guns. In the engine-room above the circulating pumps are the feed-water heaters through which the exhaust steam from the compressor engines and pumps passes, raising the temperature of the feed water to 180°.

The pressure ordinarily stored in the reservoirs is 2,000 lbs., though it is reduced to 1,000 lbs. for service in the guns. In the room occupied by the storage reservoirs there is a bank of valves working somewhat on the principle of a gate valve, but modified for the special service which they are to render; for while they are held closed by the pressure upon the back of the valve there is a small

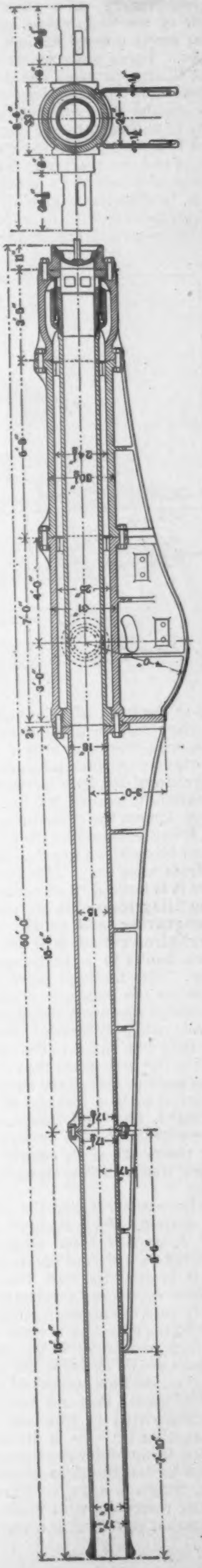


LOADING ONE OF THE DYNAMITE GUNS AT SANDY HOOK WITH A FIVE HUNDRED POUND CHARGE.

(From *Illustrated American.*)



SIDE ELEVATION OF 15-INCH PNEUMATIC DYNAMITE GUN AT SANDY HOOK, N. J.

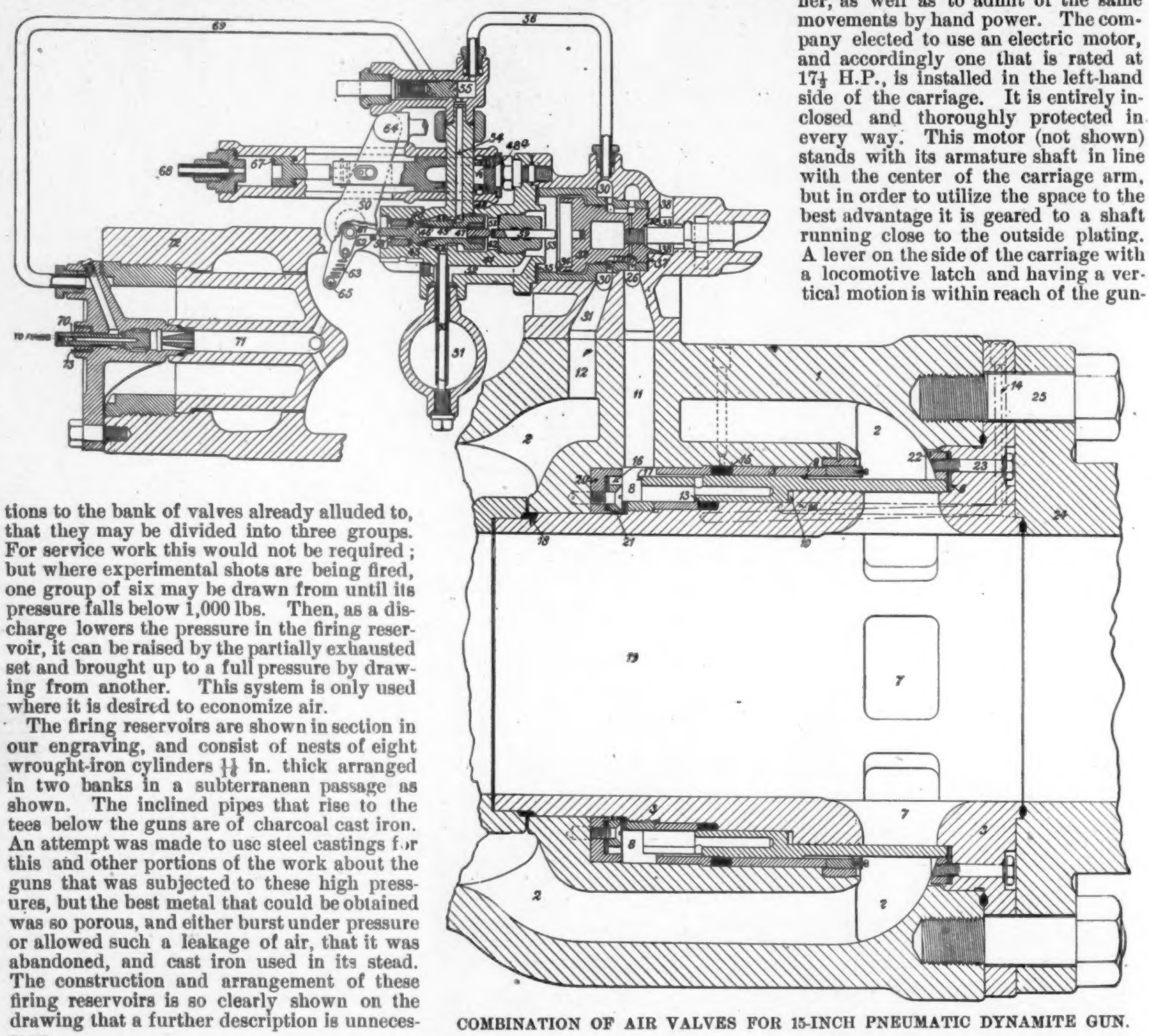


LONGITUDINAL AND CROSS SECTIONS OF 15-INCH PNEUMATIC DYNAMITE GUN.

supplementary valve that is opened by a slight play in the stem of the main valve, by which the latter is balanced and then easily opened against the great pressure existing in the pipes. These pipes are so led to and from the bank of valves that the compressors can deliver air directly to the gun reservoirs, thus pumping into the guns as it is called, or send to the storage reservoirs at the will of the attendant. It is the duty of this man to see that a pressure of 1,000 lbs. per square inch is maintained in the guns.

The storage reservoirs have a capacity of 450 cub. ft., and consist of a nest of 18 wrought-iron cylinders each 25 ft. long, 16 in. in diameter, and with shells 1/8 in. thick. The heads are welded in so that there are no rivetted joints about them. These reservoirs are arranged by means of their pipe connections to the bank of valves already alluded to, that they may be divided into three groups. For service work this would not be required; but where experimental shots are being fired, one group of six may be drawn from until its pressure falls below 1,000 lbs. Then, as a discharge lowers the pressure in the firing reservoir, it can be raised by the partially exhausted set and brought up to a full pressure by drawing from another. This system is only used where it is desired to economize air.

The firing reservoirs are shown in section in our engraving, and consist of nests of eight wrought-iron cylinders 1/4 in. thick arranged in two banks in a subterranean passage as shown. The inclined pipes that rise to the tees below the guns are of charcoal cast iron. An attempt was made to use steel castings for this and other portions of the work about the guns that was subjected to these high pressures, but the best metal that could be obtained was so porous, and either burst under pressure or allowed such a leakage of air, that it was abandoned, and cast iron used in its stead. The construction and arrangement of these firing reservoirs is so clearly shown on the drawing that a further description is unnecessary.

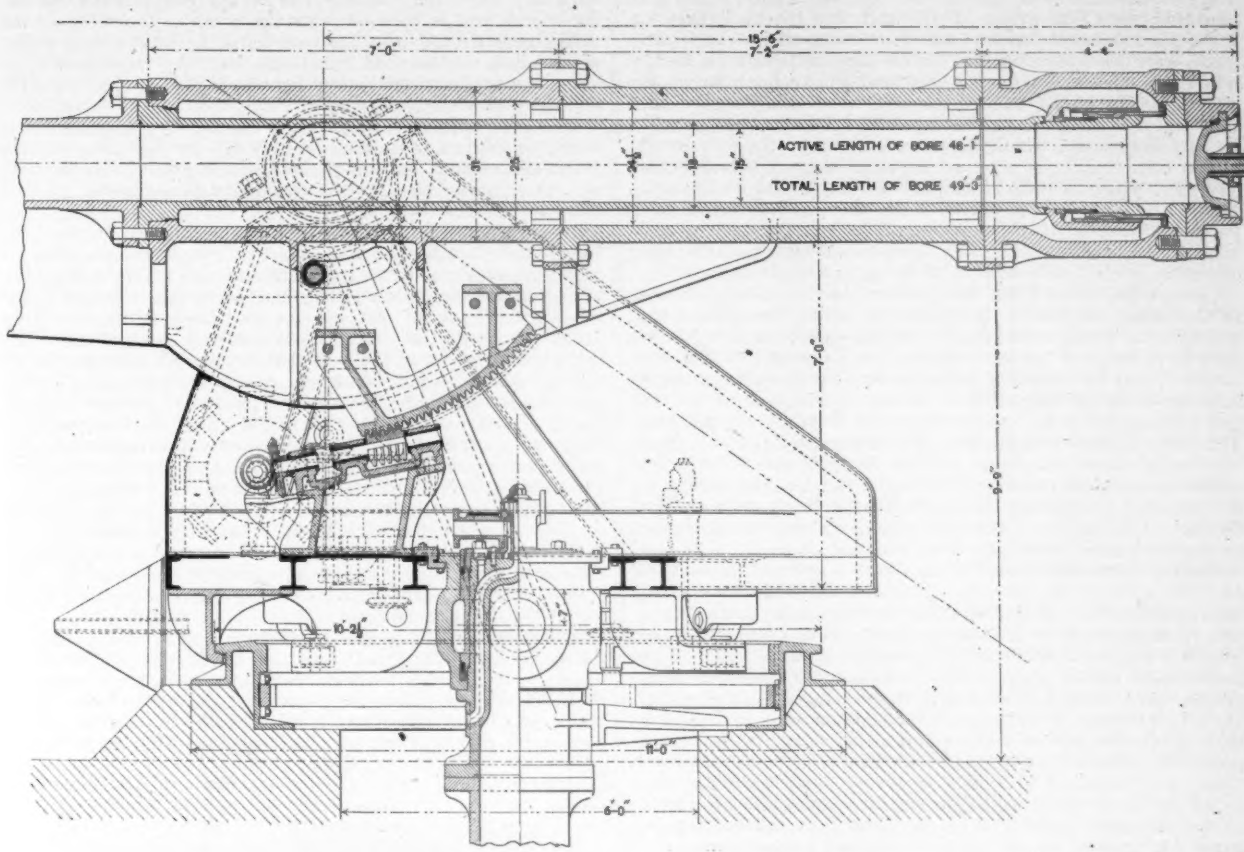


COMBINATION OF AIR VALVES FOR 15-INCH PNEUMATIC DYNAMITE GUN.

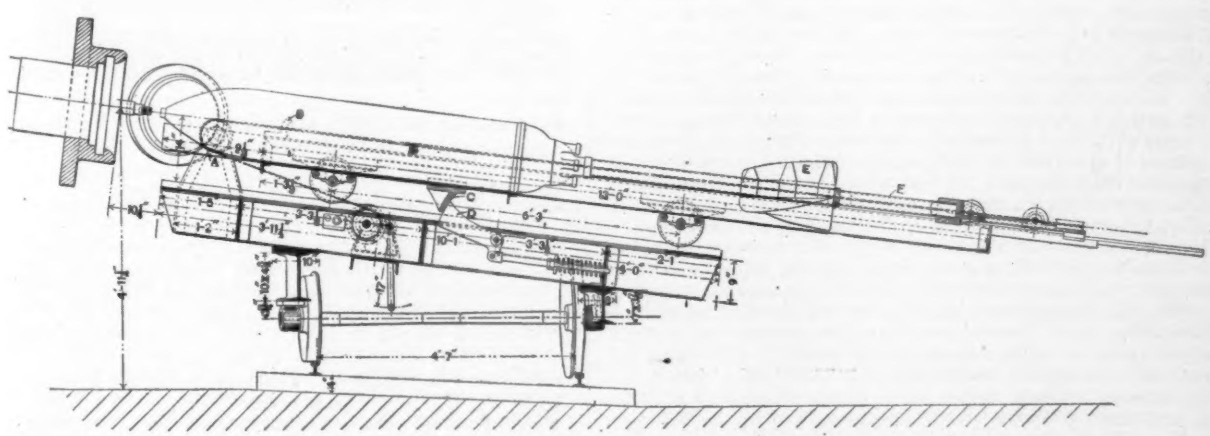
We have now reached the gun, about which the principal interest centers. As it stands it is the result of the work of Captain J. J. Rapieff, Chief Engineer of the company, who has so remodeled the original pneumatic gun that there is really nothing left beyond the bare fundamental principle; so that the ingenious valves and mechanism belonging to the gun and the cartridge are monuments of his skill.

The 15-in. gun has a total length of 40 calibers, or 50 ft. from face of muzzle to the back of the breech block. The trunnions are 35 ft. from the muzzle. The dimensions given on the longitudinal section of the gun show the various thicknesses of metal that are employed. The forward end of the gun is supported by ribs cast on the barrel, and the whole is held together by bolts as shown. Air is admitted to the gun from the firing reservoirs through a vertical connection, whence it passes to the trunnions, entering the annular space about the breech, which is always subjected to the pressure existing in the firing reservoirs with which it is connected. The joints of the trunnion and vertical connections are packed with leather cup packing. These cup packings are held out by an oil pressure from behind that is developed by admitting air under pressure into a cylinder at the right-hand side of the carriage. This cylinder carries a piston that forces a plunger down into an oil chamber, thus materially increasing the hydrostatic pressure of the latter and serving to hold the leather packing tight. Enough oil oozes through the leather of this packing to lubricate the working portions of the gun and preserve it from rust.

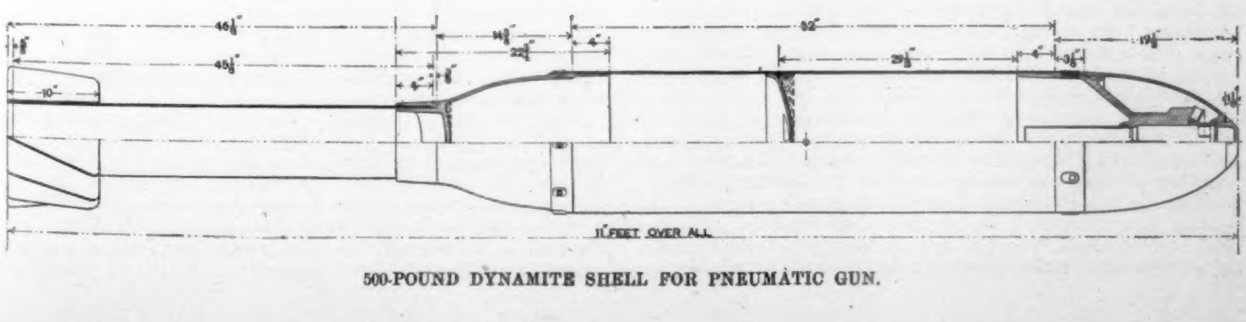
The gun is mounted on a carriage with a center pintle that allows it to traverse through a complete circle. The elevation obtainable is 35°. The specifications required that it should be trained and elevated by pneumatic or hydraulic, or, alternatively, by electric power directly under the control of the gunner, as well as to admit of the same movements by hand power. The company elected to use an electric motor, and accordingly one that is rated at 17½ H.P., is installed in the left-hand side of the carriage. It is entirely inclosed and thoroughly protected in every way. This motor (not shown) stands with its armature shaft in line with the center of the carriage arm, but in order to utilize the space to the best advantage it is geared to a shaft running close to the outside plating. A lever on the side of the carriage with a locomotive latch and having a vertical motion is within reach of the gunner, serves to connect the shaft from the motor with the elevating or training shafts, only one being in gear at once. A handwheel on a vertical shaft located just in front of the railing about the gunner's platform serves to throw the driving mechanism for elevating and training into and out of gear. This is operated by the gunner, who has his eye at the telescope, whose cross wires are to catch the target. The method of working is for the gunner to give the gun the proper elevation and then, throwing in the training gear, he brings the crosswires of his telescope on the target and fires. The connection between the shafts and the gun is by means of a worm working in a segment, as shown in the enlarged section of gun and carriage. The recoil is rigid, and is taken up by the base plate. The carriage is carried by rollers running on a circular track and provided with roller bearings, which has greatly lessened the resistances where the work is done by hand. In order to take violent strains off the rollers the shoes are fitted to the carriage, which have a bare clearance from the inside of the circular track.



BREECH AND CARRIAGE OF 15-INCH PNEUMATIC DYNAMITE GUN.



LOADING CARRIAGE FOR 15-INCH PNEUMATIC DYNAMITE GUN.



500-POUND DYNAMITE SHELL FOR PNEUMATIC GUN.

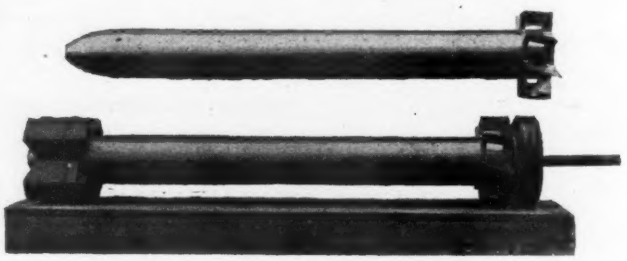
Thus far we have been dealing with comparatively simple problems in mechanics, but when the work of designing the firing mechanism was approached the difficulties to be surmounted were very great. How well this has been done we leave our readers to judge. Some of the conditions to be fulfilled were that there should be no possibility of a discharge when the breech was open; that the proper quantity of air should be admitted to secure the desired muzzle velocity, and that this quantity should be capable of being varied at will. In the engraving, which shows a section of the valves, the whole combination is grouped together to save space on the drawing, while in reality the parts are separated on the gun. Parts 70–73 are at the trunnion by the gunner's platform; parts 26–68 are at the top and side of the gun just at the junction of the breech to the annular space, as shown on the side elevation, while the remainder is in the breech itself.

Compressed air at 1,000 lbs. pressure having been obtained in the firing reservoirs, the cartridge having been put in the gun and the breech closed and entirely locked, the firing lever may be pulled and the dynamite sent on its errand of destruction. It may be remarked just here that the personal equation is no factor in the operation of the valve, and it is of no moment whether the firing lever is pulled slowly or quickly. This lever is shown on the side elevation extending down from the center of the trunnion. When the gun and firing reservoirs are under air pressures the compressed air has access to the chamber 71, holding the valve on the firing stem against its seat. Pulling the lever unseats this valve and allows the compressed air to rush past it and into the pipe 69. This air enters the chamber 48*a* and forces the stem and piston connected to the lever 60 to the left It is here that the interlocking apparatus works. Attached to the lever 60 at the point 64 is a rod running back to a latch on the breech. So long as the breech is tightly locked this latch is free, and the rod leading to 64 can be moved ahead. But as soon as the breech-locking mechanism is started this latch is caught, holding the lever to 64, which in turn prevents the lever 60 from moving, and thus stops all further action of the valve. But if, as we have supposed, the breech is closed and locked, the lever 60 is thrown ahead and the tappet 61, which is pivoted just below the center of the lever fulcrum, is thrown back and strikes the stem of the valve 47, pushing it to the right. As this is done the space 53, passage 52 and ring 44 are put in communication with the air and exhausted. At the same time the ring 49 is filled, air enters the interior through the duct 46, and the pressure in 43 acting on the larger area of the differential piston 48, causes it to jump away from 61 to the right and thus complete the exhaustion of the space 53. The annular space 2 about the breech being filled with compressed air, the latter has access to the back of the differential piston 32, and as the space 53 is exhausted this piston 32 moves to the left, passing beyond the port 27 and opening it to the atmosphere through the escape 38. As up to this time the passage 11 has been in direct communication with the air pressure in the annular space by way of ports 27, 28 and 29, the full pressure has been exerted on the surfaces 17 and 13 of the main valve to hold it against the packing 6 and close the ports 7. But when the air in 11 is exhausted the pressure in 2 acting against the shoulder 9 of the main valve, throwing it to the left and admitting air into the gun. However, as the valve 32 moves to the left, it strikes the stem 59 of the valve 47, driving the latter home to its seat and thus stopping the escape of air from 53, which immediately begins to fill again through the pipe 56 by way of the opening 30 into the annular space, the chamber 55 and the passage 54. As soon as the pressure in 53 has risen sufficiently to overcome the pressure in 30 exerted on the back of the differential piston 32, the latter moves back to the right, cutting off the escape from 11, and re-establishing communication between it and the space 2. Then the pressure in 8 being again exerted on the surfaces 17 and 13, overcomes that on the shoulder 9 and closes the main valve. This may seem a long and tedious process, but in point of fact the actual time required is less than that demanded by the usual primer to ignite a powder charge. The time during which the main valve remains open is regulated at 55, where the flow of air from the pipe 56 to the passage 54 is controlled. So as the time required for the pressure in the space 53 to rise high enough to move the valve 32 back to its normal position is varied, the opening of the main valve is correspondingly lengthened or shortened.

In order to facilitate the loading, the cartridge is placed in a cradle that is carried to the loading carriage. This cradle consists of a trough shaped to fit the cartridge and is carried on four wheels that run on the track of the loading carriage. Back of the trough there is a small trolley with a stem, *F*, extending forward from it that bears against the base of the tail tube. A wire rope is looped over the horizontal wheels at the back of this little trolley, and as it is tightened by winding on the drums shown, the cartridge trough moves forward until the clip *C* rides over by depressing the dog *D* and engages with it. Then the prolongation of the trough *A* has entered the breech and is stopped. As the winding is continued the cartridge is pushed into the gun until the little trolley comes up against the stop *B*, when the cartridge is home. The trough and its carriage is then slacked back, the breech closed, and the gun is ready for firing.

The gun with its firing valves having been designed, the cartridge with its fuse offered a problem for solution that was by no means easy, but one which Captain Rapieff has disposed of. Our engraving shows an elevation and section of the cartridge. The fuse is at the front end, the details of which the company are not quite prepared to make public. Back of the fuse is the chamber for the charge of dynamite, containing a diaphragm for steadying the load, and this is followed by the tail piece carrying wing that gives the proper rotation to the projectile. Back of the wings a gas check is placed. This drops off when the projectile is clear of the muzzle. The front end of the cartridge is so thin as to break on impact with a solid, while the interior arrangements are such as to secure an absolute explosion should the projectile plunge into the water or strike a glancing blow. The fuse is so designed that its action is certain under all conditions; it is absolutely safe from a premature explosion, and detonates its charge upon impact with a solid target either point on or with a glancing blow, and detonates the charge at the end of a given interval of time after entering the water. The fuse is 12 in. long, 3½ in. in diameter, and weighs 20 lbs. To the end of it is attached a brass case containing a priming charge of 2½ lbs. of dry gun cotton. A few grains of fulminate of mercury are used to detonate the dry gun cotton.

It may be well to remark that since the Port Royal tests of the guns on the *Vesuvius* it has been learned that fulminate of mercury, in order to detonate dry gun cotton, must be pure; that chlorate of potash will prevent the work from being done; and as this impurity existed in the fuses used at Port Royal, the results were not what they would be were the experiments to be repeated with the present knowledge on the subject.



SUB-CALIBER PROJECTILE WITH AND WITHOUT RIDERS, FOR 15-INCH PNEUMATIC DYNAMITE GUN.

The specifications for these 15-in. guns require that they shall have a range of 2,000 yds. with a shell containing 500 lbs. of explosive; 3,550 yds. with 200 lbs.; 4,500 yds. with 100 lbs., and 5,500 yds. with 50 lbs. These different charges are, however, not all put in 15-in. shells, but in shells of varying diameters; for, by a system of riders invented by Captain Rapieff, an 8-in. shell can be fired from a 15-in. gun. These are clearly shown in our photo-engraving. The binding wire is taken off when the shell is put in the gun, and the pieces drop off after the projectile is clear of the muzzle, and when these and the gas check shown at the back are gone the shell is clear for flight and destruction.

The time required for loading and firing a 500-lb. shell is limited by contract to 3 minutes, and 10 rounds must be fired in 40 minutes. For the 200-lb. shell the time is 2 minutes, with 10 rounds in 27 minutes, and for smaller shells the time limit is 1½ minutes with 10 rounds in 20 minutes. The time of manœuvring from extreme depression to extreme elevation, or the reverse, must not exceed 15 seconds, and the time of complete traversing 2 minutes.

The guns are now located on the site of the permanent battery on the shore just inside Sandy Hook. They have complete command of the whole southern approach to New York Harbor; the range of their fire extending from beyond the bar, through the Gedney Channel, over the Swash Channel to a point beyond the Romer Shoals beacon, while the Main Ship Channel is directly off the battery with the farther side not more than 1,500 yards from the guns.

THE ECONOMICAL EFFICIENCY OF LOCOMOTIVES AS COMPARED WITH STATIONARY AND MARINE ENGINES.

In a recent paper in the *Revue Générale des Chemins de Fer*, M. Desdouits, engineer in charge of locomotives and rolling stock on the State Railway of France, enters into a very complete and analytical discussion of the relative economical efficiency existing between locomotives and stationary and marine engines. He defines the coefficient of economy of any machine as being the ratio between the work received and the output. The output of a steam-engine can be measured by water or by fuel. It is evident, however, that it is the consumption of fuel which ought to serve as the final measurement of the economical work of a motor; but it is the consumption of water that is taken as a basis in order to do away with the influences exerted by differing types of boiler construction.

The work done is the *effective* work—that is to say, that which is transmitted according to the type of machine to the shaft or driving-axle. It is this work which, in the case of locomotives, we have been in the habit of designating under the name of work at the tire or tractive forces.

In default of the knowledge of the effective work, the economical coefficient is determined for marine engines and for certain stationary engines by measuring the effort exerted upon the pistons, which is obtained by means of the indicator, and which is therefore called the indicated work.

But the measurement of the indicated work will not of itself suffice for the determination of the coefficient of economy. It must be supplemented by a measurement of the passive resistance. The values thus found for the influence of passive resistance vary between 10 and 15 per cent. of the effective work in case of non-condensing engines; they remain as high as 20 per cent. for condensing engines.

In a series of very careful tests, which were made in 1882, M. G. Marié undertook to determine the economical efficiency of an engine with high tractive power. The profile chosen was a heavy grade. This circumstance permitted the exact determination of the effective work, by far the most important portion of which consisted in overcoming the gravity; consequently the uncertainty which exists regarding the value of the rolling coefficient in the total valuation was reduced to a minimum. The results of these tests ought to be considered as being very exact. The consumption of water was found to be 28½ lbs. per effective H.P. The proportion of water entrained was valued at 9 per cent. The corresponding weight of dry steam was 25½ lbs. The report of the tests did not give the average point of introduction of the steam; according to the conditions of the load and the profile, it may be taken at about 30 per cent.

In the recent experiments on the State Railway, the engines experimented with were of the type known as the two-axle coupled locomotive. The principal dimensions and the construction and operation are as follows:

Diameter of driving-wheels	6′ 6⅜″
" " cylinders	1′ 5¼″
Stroke of pistons	2′ 1.6″
Volume swept through by piston	3⅛ cub. ft.
Clearance space	.2 "
Size of ports	9″ × 1′ 3″
Maximum opening of valves... Full opening 70 per cent.	1′
Maximum opening of valves... at 25 per cent admission.	⅜
Outside lap of valves	1.2″
Inside " " "	.12″
Boiler pressure	128 and 142 lbs. per sq. in.

The first series of experiments was made on five engines which hauled the express trains between Paris and Chartres. All the tests were made on an express train between Versailles and Chartres, a run of 44 miles. The composition of the trains and the conditions of running were almost identical.

An examination of the results obtained shows at first glance a very great similarity, one might almost say an identity of economical results furnished by engines of the same construction working under the same conditions of service. It is readily understood, of course, that engines of the same construction and running at the same speed with the same cut-off ought to perform the same amount of useful work for a pound of steam consumed, at least when there was none among them where there was a loss of motor energy such as results from defective throttle-valves, valves or pistons, or from the development of abnormal passive resistances, such as insufficient lubrication, binding of the moving parts or trucks, pounding, etc.

Just here we may cite a comparative test which was made with two engines hauling a very fast train of light weight. One of the two machines was left entirely to the judgment of the driver, who in the easy parts of the line ran with a very short cut-off, or throttled the steam at the throttle-valve. For the second the point of admission was determined in advance as high as 25 per cent. When this admission was found too great for the average traction, the throttle-valve was gradually closed. The comparison of the two results shows that the engine where the cut-off was systematically maintained at a somewhat relatively high point gave practically the same results and perhaps superior to those on express trains with the same point of cut-off. The second engine, on which the cut-off was varied according to the profile of the line, showed a considerable loss of efficiency.

The table accompanying the report of this test shows that the consumption of water per effective H.P. was 29 lbs. where the engineer ran at discretion, and 25.3 lbs. where the minimum point of cut-off was fixed at 25 per cent. of the stroke.

It is clear that to proceed in a really methodical manner, and to obtain an exact comparison between the efficiency of locomotives and those of stationary or marine engines, the corresponding efficiency must be considered with reference to a predetermined speed rather than to the most favorable speed. For stationary and marine engines which are called upon to work regularly under conditions of speed and admission which are almost invariable, it can be admitted that the speed determined upon by the builder and adopted in practice corresponds practically to that of maximum economy; for a locomotive, on the other hand, it is necessary to determine from an average of special experiments the speed where the amount of work done is at a maximum. We will not insist upon this question, but will limit ourselves to recalling that this speed generally corresponds to an admission which varies very slightly from 25 per cent.

In regard to the value of inside lap in determining the efficiency of a locomotive, experiments were made upon an engine which were in every way similar to those which we have under consideration, in which the inside lap was reduced from .10 in. to .02 in. The results of the tests made showed that the engine which had been thus modified was greatly improved, and since the modification was made the engine has constantly stood at the head of the list for economical efficiency.

Accommodation and Freight Engines.—There is no real difference between engines hauling accommodation or mixed trains and freight trains, as far as the method of working steam is concerned, from those of passenger engines. The reduction in the diameter of the wheels is practically compensated for by lessening the running speed, so that the rapidity of the movement of the piston and valve, which is an important factor in effective distribution, remains almost the same. The influence of passive resistance is not *a priori* greater, for the increase of its absolute value corresponds almost exactly to that of the work done upon the pistons. Finally, it may be taken for granted that the absolute amount of work done by these engines is the same as in passenger engines.

From the standpoint of conditions of service, the engines which haul a freight train feel the influence of variations of load and the profile more than a passenger engine. It is compelled on heavy grades to run with a long cut-off, but on slight down grades and even on levels it only utilizes a small amount of its total power. We note, especially at high speeds, that running with a short cut-off is a favorable condition for economical work; for these reasons the freight engines will generally give poorer results in service than passenger engines. Experience shows that the consumption rarely falls below 26½ lbs. per effective H.P., and sometimes rises to as high as 28.7 or 30.9 lbs. These figures have a purely relative character; hence it does not seem worth while to reproduce the results of particular experiments, which are only interesting when they approach the conditions imposed in running.

The Use of Piston-valves.—The use of piston-valves, independently of other advantages which are less clearly demonstrated, secures a reduction in passive resistances which amounts to 5 per cent. of the total strain. There is nothing to prevent the accomplishment, with this system of valves, of those conditions of distribution of steam which are recognized as most advantageous in themselves. It seems, then, that it is possible to show in an engine with piston-valves a marked increase in absolute economy over engines with flat valves. In point of fact, however, this superiority has not yet been clearly shown, at least in high-speed engines. This is principally due to the fact that, in the diagrams of engines with piston-valves, an attempt has been made to gain the advantage of the small clearance spaces, which results, at least at high speeds, in an exaggeration in the compression lines. When these same engines run at an exceptionally low speed, very favorable results can be obtained.

Consumption of Dry Steam per H.P. per Hour.—In all the experiments which we have just cited, the consumption is

given in the gross weight of water which passes from the boiler to the cylinders, which consequently includes all that water which was entrained in a liquid state. No direct experiments have as yet been made in order to determine the correct proportions; all the tests which have been made agree in indicating to us that it is very slight, and probably differs but little from 5 per cent.—a proportion which is lower than that usually attributed to either stationary engines or marine engines. The results generally obtained in the experiments of the State Railways, and which are confirmed by the old drivers on the Eastern Railway as well as those of the Lyons Railway, may be given in *résumé*, as follows: The locomotive in its usual form, with the simple valve distribution, can drop the consumption of water per effective H.P. per hour to less than 24¼ lbs. Under average conditions of service with a passenger engine the consumption ranges from 25½ to 26½ lbs. of water, or from 24¼ to 25½ lbs. of dry steam. The consumption is markedly increased when running with a light load on a favorable line in which an exaggerated amount of expansion is used. The economical results furnished by a locomotive are in their totality notably superior to the most favorable results which have been made either on stationary engines or marine engines provided with the same system of steam distribution. The reason for this superiority is due to:

1. The use of relatively higher steam pressures.
2. The rotative speed being great enough to reduce the effect of cooling of the walls of the cylinder to an insignificant amount, and yet slow enough so as to cause no trouble with the conditions imposed by the flow of steam.
3. The use of the link, which is not only a very convenient method of operating the valve, but at the same time it is an excellent apparatus for variable cut-off for all points of cut-off above 20 or 25 per cent.

The conditions by which a maximum economy of consumption is obtained are:

1. A pressure which stands in the neighborhood of 142 lbs. per square inch.
2. Cylinders of moderate dimensions, permitting the service running to be carried on with a sufficiently high point of cut-off, with 20 per cent. as the minimum.
3. Clearance spaces of suitable magnitude, ranging from 6 to 8 per cent. at each end of cylinder.
4. A free exhaust obtained by doing away with inside lap of the valves or even by the adoption of a certain amount of negative lap.

Stationary Engines.—The application of the compound principle to stationary engines is almost as old as the steam-engine itself.

Neglecting the early work of Hornblower and of Watt, we find in the early years of this century a two-cylinder engine built by Arthur Woolf, who built in a very complete way an engine showing the principles and advantages of the compound system.

The Woolf system, applied to orginal steam-engines which ran slowly but regularly, and which is adapted to a comparatively low pressure, has continued throughout the whole of this century to be received with marked favor in certain industrial centers without having really supplanted the single cylinder engine. It seems to have shown from its very first application, and in spite of the low boiler pressure used, a marked economy of consumption.

While the single-cylinder engine consumed 55 to 66 lbs., the consumption of a Woolf engine would scarcely be more than 40 to 48 lbs. As the average steam pressure raised, and under the impulse due to remodelling of the marine engine, the economical efficiency of the Woolf engine as it is more carefully studied and regulated has proven an important improvement.

In some tests made at Mulhouse, in 1876 and 1878, with these engines, the entrained water being estimated at 5 per cent., the steam pressure was 70 lbs. per square inch. Taking the total of the results obtained, we find them to average 22.88 lbs. of dry steam per H.P. per hour for two vertical engines, and 22.26 lbs. for one horizontal engine.

In tabulating these results and drawing a curve we recognize the existence of a minimum of consumption which corresponds very nearly to a cut-off of one-twelfth if we consider the indicated work, and one-tenth if we use the effective work as the basis of comparison.

Marine Engines.—It is generally estimated that a saving of from 40 to 50 per cent. has been realized by the introduction of the compound system into the marine engines. But this should not be considered as entirely due to the application of double-expansion, for the increase of boiler pressure, rendered possible by the use of surface condensers, is a fact which ought of itself and outside of any special system of distribution effect an important improvement in efficiency. At the same time important improvements have been made in the mechanical arrangements of the apparatus: reduction of the volumes of the cylinders, better protection against cooling, the more general use of the direct system of connection and steeple construction, the increase in the number of revolutions per minute and the almost universal adoption of the link as a cut-off apparatus. All these modifications, which we may observe in passing have brought the marine engine to a point of close similarity to the locomotive, had their part in increasing the coefficient of efficiency. In reality, the economical results of to-day have only been obtained step by step, and not by the adoption of the compound system in itself.

Tests were made on the following vessels: *Duquesne*, 8,000 indicated H.P., the group of three Woolf engines; *Cigale*, compound two-cylinder engines, steeple; *Voltigeur*, three-cylinder compound, horizontal; *Mytho*, three-cylinder compound, steeple, in which it was estimated that the entrained water amounted to 5 per cent. of the total consumption. On the *Duquesne* the average consumption of dry saturated steam was 20.6 lbs. of dry saturated steam per H.P. per hour; on the *Cigale* it was 18.46 lbs.; on the *Voltigeur*, 18.89 lbs., and on the *Mytho*, 19.04 lbs.

If we consider the whole of the results furnished by these tests, we can say that the simple compound marine engine, working at a favorable point of cut-off and expansion, which is from four to 10 times the volume of steam admitted, will give a consumption of about 18.8 lbs. of dry steam per indicated H.P. The whole weight of feed-water will be 19.8 lbs. per effective H.P., but there is evidently no data in existence for calculating this last element to a certainty. If we accept the passive resistance at 10 per cent, the smallest proportion which has been given in the experiments in stationary engines, we obtain 20.9 lbs. of dry steam, or 22 lbs. of water per effective H.P., which seems to have been considered as a minimum.

The experiments given by Mr. Widmann permit us to determine in an approximate manner the net influence of the cut-off on the coefficient of economy. If we represent the whole of the results graphically by taking, for example, the actual fraction of admission, including the clearance space of the smaller cylinders for the abscissa and consumption for the ordinates, the grouping of the points obtained denotes the presence of a minimum of consumption at about 15 per cent admission. It may be further stated that the coefficient of consumption varies slightly when the actual admission point rises to, say, 30 per cent., or lowers to 10 per cent.; likewise in a Woolf stationary engine there exists a somewhat extended region of good efficiency.

Locomotives.—The economical results obtained in the transformation of marine engines ought to attract the attention of railway engineers. The adoption of the compound system having had as its essential object from the very start the reduction of consumption of fuel, most of the companies which have made the test have devoted themselves to showing by comparative figures the importance of the results obtained. Unfortunately this comparison is not based on a great number of cases, but upon data that has been somewhat imperfectly compiled. Most frequently new engines have been compared with other engines already in service which might differ from the type submitted to the test, not only in the system of steam distribution employed, but in power, steam pressure and general condition of repair. In all cases the results thus obtained are simply comparative, and cannot effect figures which express in any absolute manner the economical value of the type of engine under consideration. The only method which would permit an absolute certainty to be obtained is one which consists in showing, as we have already said, the results furnished by each type of engine on a common standard that has been rigorously defined, and which is nothing less than the effective work obtained therefrom. The first application of this method was made on the Southwestern Railway of Russia.

Experiments on the Southwestern Railway of Russia.—The first series of tests were carried on in the laboratory where the locomotives were arranged so as to act as stationary engines. The comparison of two engines was made: one a compound, the other a simple, exactly alike in other respects. The consumption of the compound engine was found to average about 26 4 lbs. of water per indicated H.P., while the ordinary engine consumed from 28.6 to 30.8 lbs. The consumption of both was high. This high consumption should be attributed to the fact that the two machines worked under very different conditions from that in actual service, which were clearly unfavorable from the standpoint of efficiency, as they involved a reduced pressure, slow turning and high expansion.

The second series of tests, intended to embody the same conditions as in actual work, was made in 1883 by Mr. Loewry on trains in service. The comparison was again made with an engine of the ordinary type and a Mallet machine, the first

having a steam pressure of 142 lbs. per square inch, and the second 160 lbs. The cylinders of the latter had a diameter of 16¼ in., and the other, 23.6 in. The consumption of water by the compound engine averaged 22.88 lbs. per indicated H.P. per hour; the simple engine consumed about 26.4 lbs. The 22.88 lbs. per indicated H.P. corresponded to 25.3 lbs. per effective H.P.

Still later the Southwestern Railway of Russia has made public the results obtained with four-cylinder passenger engines working under a pressure of 200 lbs. per square inch. The tests showed a consumption of 19.8 lbs. per indicated H.P., a figure which we can consider to be equal to 22 lbs. per effective H.P. It is an extremely favorable result, and one which if confirmed should cause this engine to be considered as having attained a degree of economical working which is very remarkable.

Experiments with a Compound Engine on the Northern Railway of France.—The Northern Railway of France has recently put into its express service a class of compound engines with four cylinders* working under a pressure of 200 lbs. per square inch. They are of great power, and the evenness of their running and the low consumption of water has been particularly remarkable. Great pains have been taken to establish by actual measurement the coefficient of economy of these engines, which seem to embody the most perfect type of compound locomotive that has yet been put into service.

Tests were made of these engines by the chronometer method and by the simultaneous use of the chronometer and dynamometer. They agreed in giving 22 lbs. in round numbers as the consumption of feed-water per H.P. per hour. The amount of water entrained was not measured, but it was estimated at 5 per cent. If this were the case, the consumption of dry steam amounted to about 20.9 lbs.

We had already found in the Woolf stationary engines that they consumed 22½ lbs. of dry steam, or 23.8 lbs. of water, and the simple compound marine engines (the passive resistance having been estimated at a minimum of 10 per cent.), 20 9 lbs. of dry steam, or 22 lbs. of water.

We see that the Northern type of compound locomotive showed results at least as economical as those given by the stationary Woolf engines or the compound marine engines working condensing.

The absence of the condenser was compensated for by the use of a higher pressure, a greater rotative speed and probably lower passive resistances. The figures of the Northern engine, compared with the results obtained from the ordinary locomotives, are more remarkable in that the experiments were made at high speed, ranging from 46.6 to 51.5 miles per hour, where it was possible the point of maximum efficiency was passed.

It should be understood that the economical results given by these tests should be attributed to the particular type of engine experimented with, and not in any way to the general type of compound locomotives. The compound arrangement is capable of introducing a great variety of variables that may have a greater influence on its economy than those existing in ordinary engines. If in the case before us they have by careful study succeeded in regulating these different elements in the best possible manner—that is, the pressure, the area of steam passages, clearance space and intermediate receiver, point of cut-off in the two cylinders, etc.—it is clear that these same elements could be combined in another engine so that they would show less favorable results; the benefit of the compound arrangement would then be lessened, and might perhaps entirely disappear.

It has been impossible to investigate the variations to which the efficiency would be subjected at different points of cut-off and at different speeds. The test, however, seemed to have established the fact that for moderate speeds of from 45 to 50 miles per hour the efficiency does not vary very much from its maximum when the effective expansion varies from 4 to 10.

Corliss Engines.—Numerous reports of experiments concerning the efficiency of the Corliss engines have been published, most of them emanating from their builders. The figures are necessarily somewhat confusing, and some claim a degree of economy that it would be difficult to accept without further investigation. We will limit ourselves to the reproduction of the experiments made at Creusot in 1883, a *résumé* of which was published by Mr. Delafond. These tests, by reason of the extreme care which was taken in all of the measurements, and the number and variety of the tests, can be considered as fixing under the seal of the best possible authority the practical coefficient of economy of the Corliss engine.

The engine tested was rated at about 200 H.P.; the work was measured in effective and indicated H.P. The ratio of the two kinds of measurements gave the value of the passive resistances. Furthermore, and this is of special interest from a standpoint of comparison of marine engines and locomotives, they worked successively with and without the condenser.

Test with the Condenser.—The results obtained while running with the condenser permit the Corliss engine to be compared with compound marine engines or with Woolf stationary engines. The tests were made with pressures ranging from 55 lbs. to about 115 lbs. per square inch. They show that the highest pressure gave the most favorable results. With the boiler pressure of 110 lbs. per square inch the following results were obtained for water consumption at different points of cut off:

Cut-Off.	Indicated H. P.	Effective H. P.
.055	16.81 lbs.	21.43 lbs.
.067	16.47 "	20.65 "
.125	17.37 "	21.01 "

The uniform speed was 60 revolutions per minute. The cylinder had a steam jacket. The results of these tests show that a very short cut-off (from 6 to 7 per cent.) has a favorable influence on the efficiency, but it is necessary to note that where the distribution is made by means of a catch the actual point of cut-off is always a little later than the apparent.

Tests without the Condenser.—Tests without the condenser can be made with and without the steam jacket. The use of the steam jacket was shown to have an advantage at least in case of moderately high speeds. The steam pressure was varied between wide limits even when running with the condenser, and the most favorable results were attained with the highest pressure. Under these conditions the following figures for water consumption have been obtained for different points of admission:

Cut-Off in Per Cent. of Stroke.	Indicated H.P.	Effective H.P.
11	22.49 lbs.	26.61 lbs.
13	21.82 "	25.35 "
16	22.05 "	25.04 "
20	21.20 "	23.68 "

The speed was 60 turns per minute.

We may state here that, contrary to the observations made when running with a condenser, short points of cut-off are unfavorable, and the efficiency increases when the point of admission rises to 20 per cent. The most favorable point of cut-off in all these series of tests was obtained at 20 per cent.—23.68 lbs. of water per effective H.P. per hour, or 22½ lbs. of dry steam. The diminution in efficiency due to the removal of the condenser caused a drop of about 15 per cent.

Locomotives.—The application of the Corliss release has been recently attempted on locomotives. It does not, however, seem well adapted to the wide range through which locomotives are called upon to work with their quick variations, together with the necessity of running in opposite directions.

The State Railway put a number of high-speed engines at work in 1889. They were designed by M. Bonnefond, who by arrangement of simple mechanical appliances seemed to have surmounted the many difficulties which beset this problem.

These engines were tested on the run from Château-du-Loir to Courtalain, on a section where there was a steep grade of 1 per cent. for more than 6 miles. In order to determine the influence of speed on one of the trials, the whole run was divided into two parts—the first being almost perfectly level, the second being entirely on this grade. The average results were almost exactly 22 lbs. of water per H.P. per hour, the figures agreeing with those obtained by the Northern compound engines.

On the other hand, the efficiency rose with the speed, a result which ought not to surprise us; the excess of compression which, in single-valve engines, manifests itself at high speeds, being avoided, thanks to the independence of the exhaust, so that a benefit was derived from the thermic advantages inherent in high velocities.

Résumé and Conclusions.—The observations made and analyzed in this paper lead us to a number of conclusions which can be given in a few words:

First, the locomotive engine, considered either under its usual form with a single valve, or under the improved form, resulting from the application of the compound system, or with a Corliss valve, is susceptible of an economic efficiency

* See American Engineer, page 114, March, 1893.

as favorable as the best stationary or marine engines having the same system of steam distribution, in spite of the advantages which these latter derive from the use of the condenser. When making a comparison with these same engines working without a condenser, the locomotive has a marked advantage.

Second, the consumption of water in a locomotive with single valve under favorable conditions as to the cut-off and pressure can be lowered to less than 24.25 lbs., including entraining, or to 23.15 lbs. of dry steam per effective H.P. per hour.

The consumption of 23.15 lbs. of water or 22 lbs. of dry steam can be considered as the limit corresponding to the most perfect condition of regulation. The use of the compound system (four-cylinder type of the North of France) permits the consumption of water to be lowered to 22 lbs. or to 20.9 lbs. of dry steam per effective H.P. per hour. The use of the Corliss type of steam distribution, such as the Bonnefond type on the State Railway of France, has given exactly equivalent results—22 lbs. of water, or 20.9 lbs. of dry steam per effective H.P.

Third, in the case of a locomotive with the ordinary valve the most favorable conditions of economical consumption are as follows: A pressure of about 145 lbs. per square inch; moderate-sized cylinders permitting a cut-off at 20 per cent. of the stroke to be regularly used; steam passages opening freely into the admission ports, and especially into the exhaust; an ample clearance space of from 6 to 8 per cent. at each end of the stroke; a moderately high speed of rotation without being excessive, ranging from 150 to 200 turns per minute.

Under the usual conditions of construction and regulations of our locomotives, the consumption varies from 24.25 to 26.5 lbs. when the running conditions require a somewhat high power to be developed at a moderate speed. The consumption rises to 28.75 lbs., and under exceptional conditions to a still higher figure, in consequence of special conditions of running and profile, so that it may become necessary to use a cut-off that is too long or one that is too short, or even wire-draw the steam at the throttle-valve. The use of a cut-off that is too short, or an exaggeration of the wire-drawing of the steam, can always be avoided by intermittently opening and closing the throttle valve. Under these conditions the consumption of an engine in good condition will always be maintained at less than 26.5 lbs., except in rare cases of very heavy grades or high speed.

Fourth, the application of the compound system seems to require, as a condition of really advantageous employment, a higher pressure of steam ranging from 170 lbs. to 200 lbs. per square inch; it requires that the steam passages should be large and that the clearance spaces should have a high capacity. Under these conditions it is possible to carry the ratio of expansion higher than with the ordinary engine. The use of very high expansion does not give increase of economy, but involves a loss of efficiency less than in the case of single-cylinder engines.

In this sense, then, it may be said that the compound engine gives the locomotive a greater suppleness for adapting itself to variations of load and profile. Too high a speed causes a loss of efficiency to appear through the increase of compression, just as it does in the case of the ordinary engine.

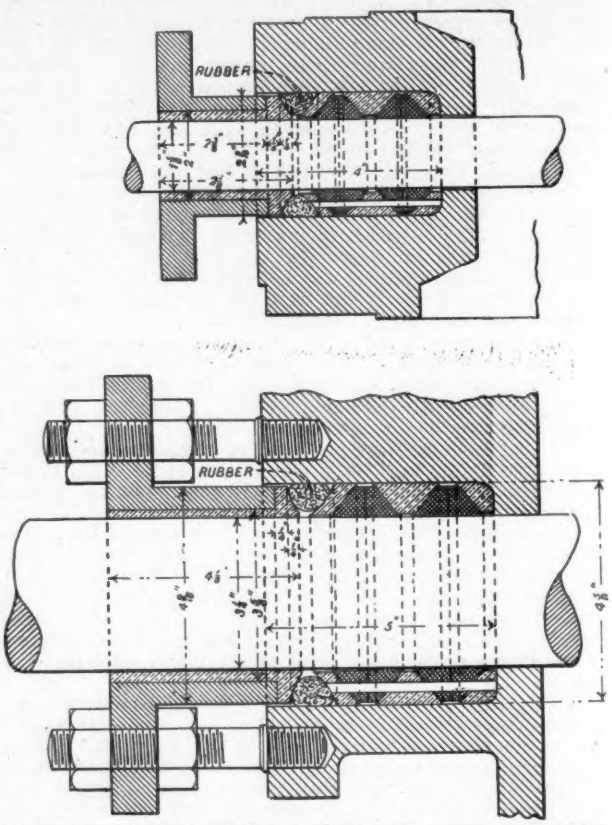
Fifth, steam distribution with multiple valves permit the pressures of from 170 lbs. to 200 lbs. per square inch to be advantageously used, but without the use of a very high pressure being essential to their action. Just as in the compound system they permit a marked increase in the ratio of expansion to be used without resulting in any sensible loss of efficiency. Owing to the independence of the exhaust they are not subjected, like engines with the ordinary methods of distribution, to excessive compression at high speed. They seem destined to effect a maximum of economy in water consumption on high-speed trains.

SOME SPECIAL APPLIANCES IN USE ON THE FLINT & PÈRE MARQUETTE RAILROAD.

TORPEDO-CASE.

When the equipment of the rear brakeman consisted of two lanterns and a flag, there was little or no difficulty in his handling them without hindering his own free motions; but since the fusee and the torpedo have been added to his outfit, his hands are too full for quick and convenient work in changing trains and in properly protecting the rear end of his train. It has, therefore, become necessary that some sort of case should be devised in order that as many of these pieces shall be contained in one bundle as possible.

We illustrate herewith a very convenient form of case devised by Mr. T. J. Hatswell, Master Mechanic of the Flint & Père Marquette Railroad. The dimensions of the case are all given on the drawings, the external diameter being 3¼ in., with a total length of 26½ in. At one side there is a partition for a flag, the larger portion of the space being occupied by a chamber to hold the fusees. At the other end there is a torpedo-case whose cap is held in position by a bayonet motion; a hook on the handle provides for a lantern attachment, so that if the man has his lantern and his case, everything can be carried in one hand. This, of course, does not include extra lanterns or signal lights, but they can be bunched and gathered in one hand; while on going back, the man simply is to pick up one thing and he is thoroughly equipped with fusees, flag and lantern.



METALLIC PACKING, FLINT & PÈRE MARQUETTE RAILROAD.

METALLIC PACKING.

The metallic packing illustrated herewith is very simple in construction and efficient in service. The single cross-hatched lines denote cast iron, the dotted hatching is brass and the double hatching is soft metal. It will be seen that the rings are beveled. The backing of the soft metal rings which comes down against the rod is vertical to the center line of the latter, while the brass rings are beveled, but are not in two pieces. The action is exceedingly simple, as a gland screwed in the beveled face of the brass forces the soft metal down against the rod, while it in turn is sprung out against the larger diameter of the stuffing-box. A piece of rubber serves to cushion the pressure exerted by the gland against the brass, and to avoid the danger of metal to metal contact causing a rigid cramping of the rings. The rings are split in order to allow for radial expansion and contraction, and the cast-iron gland is bushed, as it may be seen, with brass.

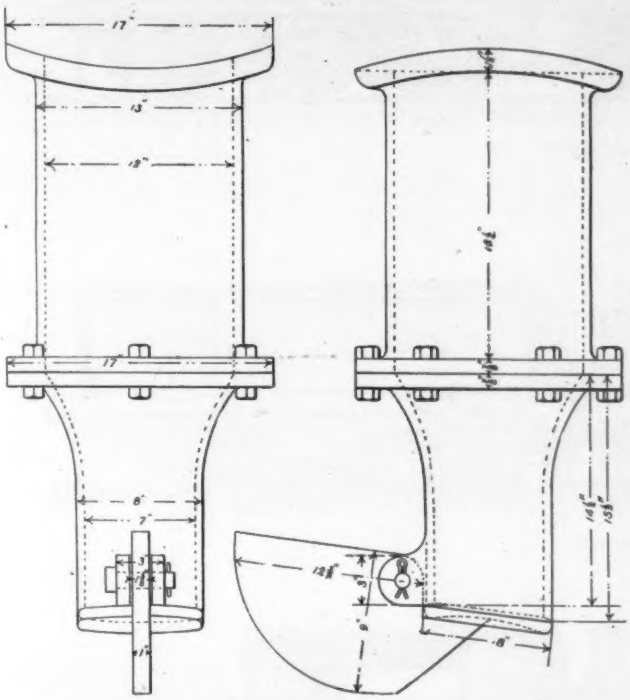
CINDER TRAP.

Mr. Hatswell has in use an exceedingly simple cinder trap for the front end of his locomotives. There are no slides, no wearing parts and nothing to get out of order or to leak; the construction is so simple that comment or description is almost unnecessary. The bottom of the drop is pivoted at the point shown just above the lower end of the shute, and consists of a slightly convex plate fitting into the bottom of the shute and held there by the counterweight extending out at the left of the pivot. The dimension of the drop is given on the engraving so clearly that any mechanic can reproduce it.

MR. MAXIM'S FLYING MACHINE.

The London *Times* of August 3 contained the following account of the recent trial of Mr. Maxim's flying machine :

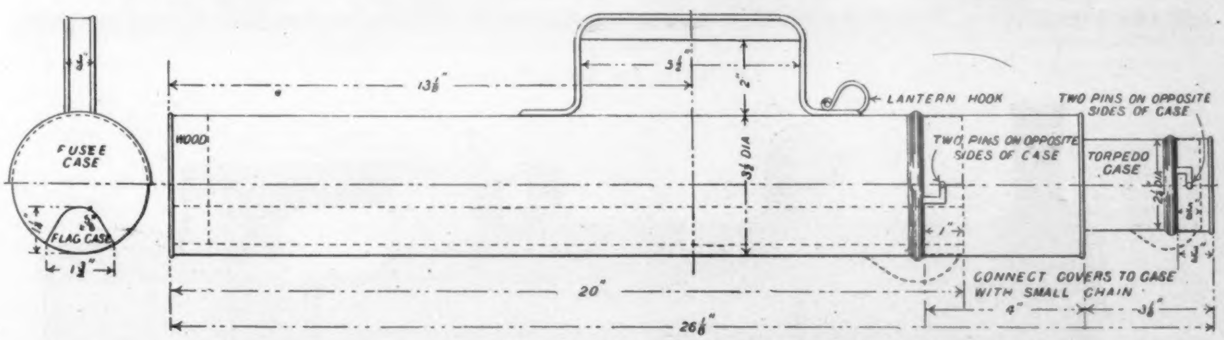
" For some years past Mr. Maxim, as is well known to our readers, has been carrying out experiments with a view to constructing a machine able to propel itself through the air. His efforts have now been crowned with success. On Tuesday last, he, together with two of his men, traveled through the air on his flying machine for a distance of some 500 ft. This, of course, does not mean that the problem of aerial locomotion has been completely solved ; on the contrary, very much has to be done before flying will be practicable for the human race. What Mr. Maxim has done is to show that it is possible to make a machine combining so much power with extreme lightness of construction as to be able to travel through the air, carrying its water, its fuel and its engineers with it.



CINDER TRAP, FLINT & PÈRE MARQUETTE RAILROAD.

For his experiments, which have been conducted near Bexley, in Kent, Mr. Maxim has laid down a track of light railway some 1,600 ft. long, on which the machine runs. On each side of this railway, and standing about 2 ft. above it, is an inverted track of strong timber. From each side of the machine there project two arms carrying flanged wheels, which press against the lower side of the timber track whenever the machine rises more than an inch or two from the rails, and so prevent it from soaring into the air. On Tuesday, as is plainly shown by the marks on the timber, the machine, almost directly after starting, rose from the metal rails and sailed along for some hundreds of feet, held down by the outside check-rail. It would doubtless have gone the whole length of the railway but for an unfortunate accident. Mr. Maxim, calculating that the main stress would fall on the forward pair of projecting arms, had made the pair behind somewhat too weak, so that they bent under the strain they had to bear. In this way the back part of the machine was liberated from the control of the check-rail, and naturally began to sway violently. The front wheel on the left hand side in consequence jumped the rail, and the only remaining guide wheel plowed into the timber, broke off one of the posts, smashed its flange, twisted its axle and liberated the machine from the track altogether. It was then soaring at a considerable angle when it was brought to a standstill, considerably damaged, on the turf by Mr. Maxim's shutting off steam. Here, then, is certain evidence that it had really flown and had not merely run along the rails. The turf is not at all plowed up, as it would inevitably have been had the machine slipped off the rails and run along the ground. On the contrary, the wheels have sunk cleanly into the earth, just as they would have done had the machine been dropped down perpendicularly, as in fact it was. These and several other facts are amply sufficient to prove that it really did rise from the rails, even without the testimony of the witnesses who were specially placed to observe what occurred.

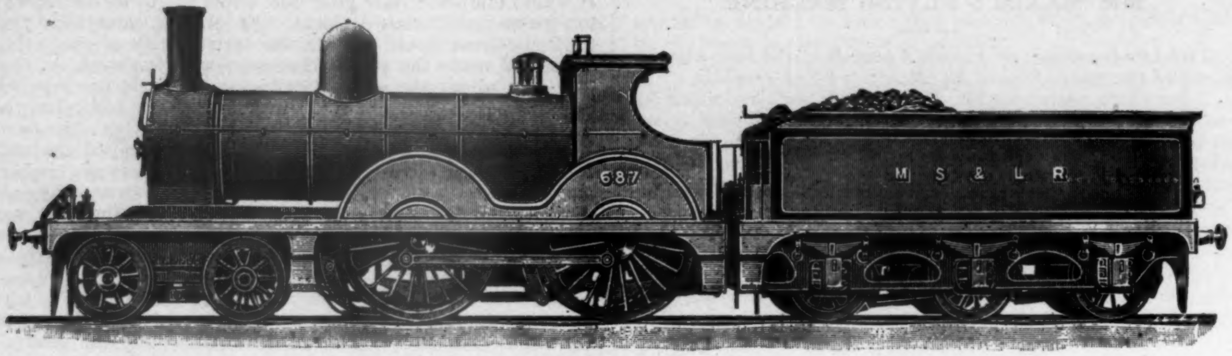
" The machine from which this striking result has been obtained is a marvel of engineering ingenuity. With its four side sails and ' aeroplanes ' set, it is over 100 ft. wide, and is described as looking like a huge white bird with four wings instead of two. It is propelled by two large two-bladed screws, resembling the screw propellers of a ship, driven by two compound engines, which are, in proportion to their weight, the most powerful that have ever been made. They can develop 1 H.P. for every 2 lbs. of their weight. The boiler is of novel design, and consists of very many tiny tubes, through which there is a forced circulation of water. It is so efficient that the pressure can be raised from 200 lbs. per square inch to 300 lbs. in about a minute, and is more than capable of supplying steam to the engines even when they are making 500 revolutions a minute. In Tuesday's successful trial Mr. Maxim started with a pressure of 310 lbs , which had risen to 320 lbs. when he had traversed some 500 yds. To realize the full meaning of this result, it must be remembered that these 500 yds. were run at the rate of 45 miles an hour, the propellers making some 500 revolutions per minute. The fuel used was gasoline. The total weight of the machine on Tuesday was about 8,000 lbs., while the engines were given a lifting power of about 10,000 lbs. There was thus a surplus flotatory power of some 2,000 lbs., or, in other words, the machine could have flown with something near that amount of extra weight above what it actually carried. It was, of course, this 2,000 lbs. of surplus lifting power that did all the mischief, by throwing on the controlling axles a strain they had not been designed to bear. After such an experiment few engineers will in future be found willing to deny, as some have in the past, the possibility of constructing an aerial vessel so powerful and yet so light as to be able to propel itself and its crew through the air, together with water and fuel sufficient for a voyage."



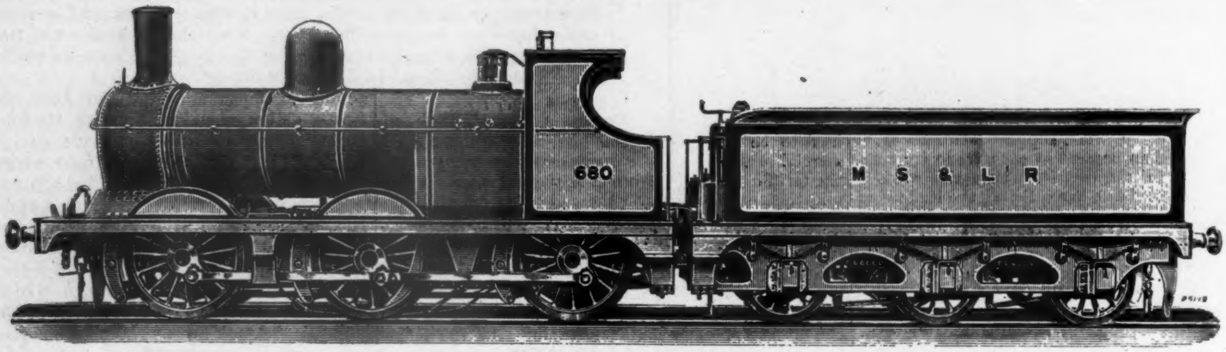
TORPEDO CASE, FLINT & PÈRE MARQUETTE RAILROAD.

STANDARD LOCOMOTIVES ON THE MANCHESTER, SHEFFIELD & LINCOLNSHIRE RAILWAY.

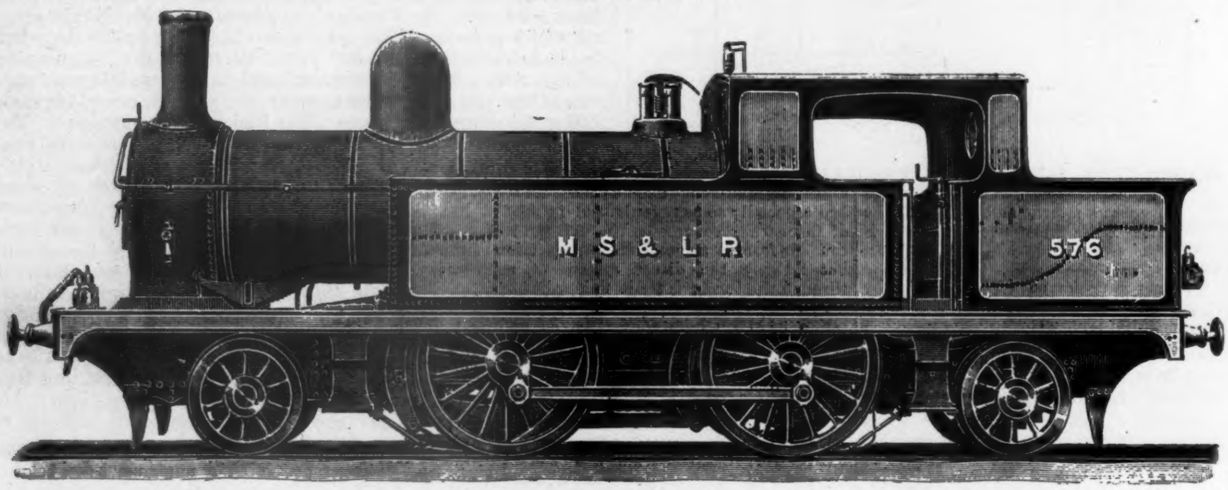
We republish herewith from *Engineering* a set of engravings showing the types of standard locomotives in use on the Manchester, Sheffield & Lincolnshire Railway, in England. They were designed by Mr. Harry Pollitt, the locomotive superintendent for the line. The main particulars regarding these locomotives will be found in the following list of dimensions :



EXPRESS LOCOMOTIVE.



GOODS LOCOMOTIVE



LOCOMOTIVE FOR LOCAL TRAFFIC.

GOODS TANK LOCOMOTIVE.

TYPES OF STANDARD LOCOMOTIVES, MANCHESTER, SHEFFIELD & LINCOLNSHIRE RAILWAY.

Express Locomotive:	Ft.	In.
Diameter of cylinders	1	6
Stroke " "	2	6
Diameter of bogie wheels	3	6
" " coupled wheels	6	9
Distance between centers of bogie wheels	5	9
" from center of bogie trailing wheels to center of driving wheels	7	5
Distance between centers of coupled wheels	8	7
Total wheel base	21	9
Boiler pressure	160 lbs. per sq. in.	

	Tons.	Cwt.
Weight loaded: On bogie	13	19
" " " driving wheels	16	10
" " " trailing "	15	11
Total	46	0

Tender:	Ft.	In.
Diameter of wheels	3	9
Wheel base	13	0
Capacity of tank	3,000 galls.	
Total weight loaded	35 tons.	

Goods' Locomotive:	Ft.	In.
Diameter of cylinders	1	6
Stroke	2	2
Diameter of coupled wheels	5	1
Distance between centers of leading and driving-wheels	7	11
" " " " driving and trailing-wheels	8	7
Total wheel base	16	6
Boiler pressure	160 lbs. per sq. in.	

	Tons.	Cwt.
Weight loaded: On leading wheels	14	14
" " " driving "	15	8
" " " trailing "	13	8
Total	43	10

Tender:

Same as for express engine.

Locomotive for Local Traffic:	Ft.	In.
Diameter of cylinders	1	6
Stroke	2	0
Diameter of radial wheels	3	6
" " coupled wheels	5	7
Distance between centers of front radial wheels and driving wheels	7	10½
Distance between centers of coupled wheels	8	7
" " " " hind coupled wheels and hind radial wheels	7	0
Total wheel base	23	5½
Boiler pressure	160 lbs. per sq. in.	
Capacity of tanks	1,400 galls.	

	Tons.	Cwt.
Weight loaded: On leading wheels	12	6
" " " driving "	17	18
" " " hind coupled wheels	16	8
" " " " radial wheels	12	8
Total	59	0

Goods' Tank Locomotive:	Ft.	In.
Diameter of cylinders	1	6
Stroke	2	2
Diameter of coupled wheels	5	1
" trailing (radial) wheels	3	6
Distance between centers of leading and driving wheels	7	11
" " " " driving and hind coupled wheels	8	7
" " " " hind coupled wheels and trailing wheels	6	0
Total wheel base	22	6
Boiler pressure	160 lbs. per sq. in.	
Capacity of tanks	1,400 galls.	

	Tons.	Cwt.
Weight loaded: On leading wheels	15	4
" " " driving wheels	16	3¼
" " " hind coupled wheels	14	18
" " " trailing wheels	13	13
" "		
Total	59	18¾

A SUCCESSFUL ARBITRATION.

THE only case in three years where an umpire's services had to be called in to settle a disputed question of wages under the form of arbitration adopted by the National Association of Builders, is that the report on which will be found below, and of special interest in view of the present condition of the labor question:

DECISION OF UMPIRE OF JOINT COMMITTEE, MASON BUILDERS' ASSOCIATION AND BRICKLAYERS' UNION.

I have carefully considered the arguments on each side of the contention between the Mason Builders' Association and the Bricklayers' Union No. 3 of Boston and vicinity, as given at the hearing Wednesday, June 27, and herewith state briefly the points at issue and the conclusion forced upon me.

The members of the committee of the Mason Builders' Association aver that, in consequence of the present depressed condition of business, building has decreased, values have declined, and that, at the former rate of wages and material, there is no inducement for owners of real estate to venture on new enterprises. They, therefore, ask that the reasonable reduction in wages of bricklayers of four cents per hour, or about 10 per cent., be yielded, from date to January 1, 1895. The present agreement is on the basis of 42 cents per hour and eight hours a day, overtime to be paid for at an added rate of 50 per cent , or " time and a half," as it was expressed.

Collateral arguments and instances were adduced, but the above is the chief ground upon which abatement is asked. Selfish interest was disclaimed, and the lessened wage, the builders believed, by stimulating business, would result in more and steadier work for the bricklayers.

To which the members of the committee representing the Bricklayers' Union rejoined:

First, that the gravity of the alleged depression was exaggerated, and they endeavored to show from figures obtained at the office of the Inspector of Buildings that the first four months of 1894 show an increase in the number of completed buildings above the same period of 1893, implying that the hard times had failed to materially injure the building business.

Second, a weighty reason why wages in Boston should not be cut was their present low rate as compared with other cities of the country, New York, Baltimore, Indianapolis and Denver paying 50 cents per hour; Philadelphia, 45 cents; St. Louis, 55 cents; and Cincinnati, 56 cents; all on a day of eight hours. Buffalo pays 36 cents and St. Paul, 45 cents, both on a day of nine hours.

Third, the irregularity of work and the large amount of time lost through enforced idleness—not only from cessation of outside bricklaying in wintry weather, but from unavoidable delay of material and waiting for other mechanics at all times—really reduces the seemingly high rate of wages to a low average. It was affirmed, and not denied, that the average workman does not earn over $11 to $12 per week, or about $600 per year.

Other contentions there were, but the three given cover the points deserving attention.

The amicable spirit of both parties and the evident desire to arrive at a just conclusion were manifest. In the same spirit let me consider the points raised.

I agree with the Mason Builders' Committee that the present depression is serious; that buildings have been put up on speculation in excess of the demand; that new enterprises are checked, contracts are few, and that the large number of empty houses for sale and the numerous idle bricklayers are sufficient to show the situation. I am not convinced, however, that a small abatement of mechanics' wages will stimulate new business.

The first contention of the Bricklayers' Union Committee is baseless and misleading. The increased number of buildings completed in the first four months of 1894 does not disprove the great depression, for it is evident that the initiation of these completed buildings antedates the panic. If the dates of beginning and the length of time occupied in the building were given, the statistics would be found valueless in this discussion.

The second objection urged against the cut of wages proposed is the comparative low price paid in Boston when the other great cities are considered. On its face it is a strong point, but conditions are always found on examination to account for the discrepancy. If there were no counter-balancing advantages in living in Boston over living in Cincinnati, it is safe to say that with bricklayers' wages at 56 cents per hour in the latter place as against 42 cents here, there would be a hegira of workmen from this city to that. But the fact remains that, instead, bricklayers are drawn to Boston, and, as appeared in the testimony, from cities where the nominal wage is higher.

An agreement of 50 cents per hour in Denver means nothing when building is paralyzed, as at present, and employment in that line practically suspended.

The third reason for leaving undisturbed the current pay has decided force, correcting the unwarranted conclusion that large wages per hour are necessarily large in the gross, as was

THREE-TON TRAVELING CRANE AT THE SHIPYARDS OF THE F. W. WHEELER CO., WEST BAY CITY, MICH. BUILT BY THE BROWN HOISTING & CONVEYING CO., CLEVELAND, O.

satisfactorily explained, by unsuitable weather and inevitable delays from causes beyond the bricklayers' control.

I deem it unnecessary to elaborate further the arguments or pleas advanced on both sides, and proceed to give the conclusion I have reached.

If the hard times and the dullness in building were caused by excessive wages paid to bricklayers and other similar mechanics, there would be ample reason for granting the mason builders' request. But it is evident that such is not the case, and that some undefined cause makes the lot of both parties a trying one. Attempting to curtail the earnings of either cannot, therefore, be effective. Moreover, the mason builders have this advantage, they enjoy opportunities for profits on contracts that may furnish a fund with which to tide over such times as the present. The bricklayers have no chance for exceptional profits, and while their wages may be adequate to support themselves and families in prosperous times, they are in trouble when work fails them.

Again, for the mechanic to raise his wages is a hard and slow process, and if lowered to meet an emergency, involves great exertion to recover them as times improve. They are, consequently, the last item of expense to be deliberately reduced.

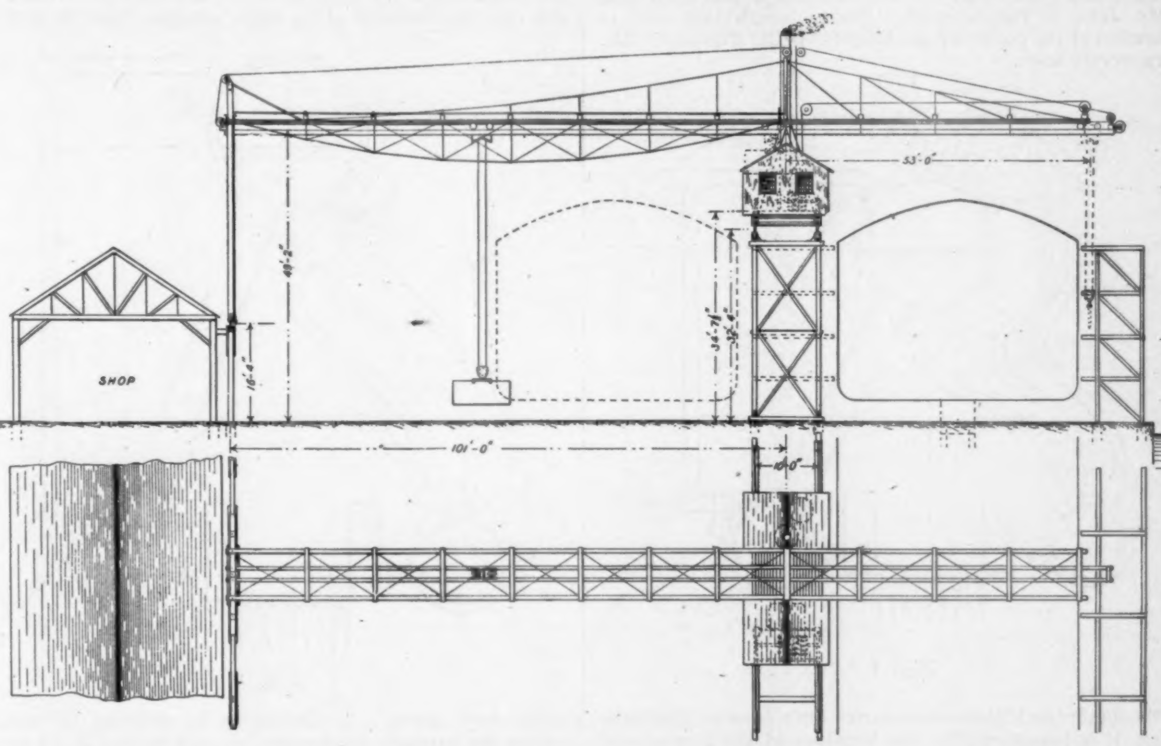
instituted this fair and reasonable method of adjusting your differences of opinion. Respectfully,

(Signed) WILLIAM LLOYD GARRISON,

BOSTON, July 6, 1894. *Referee.*

THE BROWN TRAVELING CRANE.

THE illustration on page 408 represents the shipyards of F. W. Wheeler & Co., at West Bay City, Mich. The building at the left is the forging and bending shop, where the form irons for the iron vessels are bent and the plates rolled to shape. On the right there is shown the scantlings of a vessel in course of construction, while the traveling crane used for carrying material from different points about the yard to vessels on the stocks is shown in the act of conveying a sheet from the shop to the boat. This crane was built by the Brown Hoisting & Conveying Company, of Cleveland, O., and has a span of 101 ft. from center to center of supporting piers, with a cantilever extension over the vessel on the building berth that allows the carriage to travel 53 ft. beyond the center of the pier. One end of the bridge rests on a single pier on a single-rail track, while the cantilever end is on a double track that is



THREE-TON TRAVELING CRANE, BUILT BY THE BROWN HOISTING & CONVEYING COMPANY, CLEVELAND, O.

It may pertinently be asked, if wages were fixed at 36 cents instead of 42, who would benefit by the concession? Chiefly the mason builders, who have unfinished contracts estimated at the higher figure. It would be a transfer without consideration from the laborer to the employer. New contracts would be figured on the cut rate, and unless increased building resulted from diminished wages, nothing would be gained.

My own belief is that the primal cause of the cessation of building centers in the excessive and speculative advance in land values (aggravated by the financial distrust of our national credit), and that the return of better times must be preceded by the decline of the prices demanded for land. When they fall, capital will again be encouraged to invest in new buildings. Land values are the last thing to decline in a panic, but until they do, enterprise is checked and labor waits. The real enemy against whom both builders and employés should unite is land speculation, for he who controls the opportunity controls also the profits of him who uses it.

Convinced, therefore, that no general gain will accrue to the mason builders by the cut of the bricklayers' wage, and that the amount is too small to signify for the stimulation of business, I, therefore, decide that no abatement from the current rate be made.

Permit me to express my gratification, in view of the deplorable labor conflict now raging in the West, that you have

10 ft. from center to center of rails. The engine and boiler house is located over the double-track pier. The house is built of corrugated iron, and contains a specially designed double engine fitted with patented band friction clutches. The cylinders are 8½ in. in diameter, with a piston stroke of 12 in. This engine drives one hoisting drum 36 in. in diameter with a 9-in. face, and two racking and traveling drums each with a diameter of 36 in. and a face of 7 in. Steam is supplied by an upright boiler 48 in. in diameter.

The entire structure is of iron with the exception of the tramway, track stringers, cross beams and frame of the engine house.

The capacity of the crane is rated at 6,000 lbs., and the drums are so geared to the engine that a hoisting speed of 150 ft. per minute is obtained. The speed of the trolley is 500 ft. per minute, and that of the whole structure 200 ft. per minute.

When we compare the ease and facility with which all parts entering into the structure of a vessel can be put in position by such a machine, we can readily see the force of the claim on the part of the owners that the crane paid for itself in six months—that is, the difference in cost of handling material by machine, compared with the cost of handling by the methods previously employed, amounted to the cost of the machine in six months.

The line engraving of the crane shows it with two vessels beneath it, and this can be readily done where end launching is used; but where side launching prevails, as in the yards of F. W. Wheeler & Co., no vessel can be located where the one shown by the dotted lines is placed. In this particular instance the central vessel is not built, and the crane travels down a long line of building berths from which the vessel is launched sideways into the water that is indicated at the right of the engraving. We do not wish to be understood, however, as stating that the end or stern launch is not used in these yards as it is, but the side launch has also been employed for many of the largest vessels built by the firm.

THE INFLUENCE OF CIRCULATION ON EVAPORATIVE EFFICIENCY OF WATER-TUBE BOILERS.

In our issue for June we published a paper on water-tube boilers, and the discussion thereon by the members of the American Society of Mechanical Engineers. Those of our readers who have followed the matter will be interested in a paper recently read before the Institution of Naval Architects by Mr. John I. Thorneycroft. For the engravings used in illustration of the paper we are indebted to the *Engineer*. Mr. Thorneycroft said:

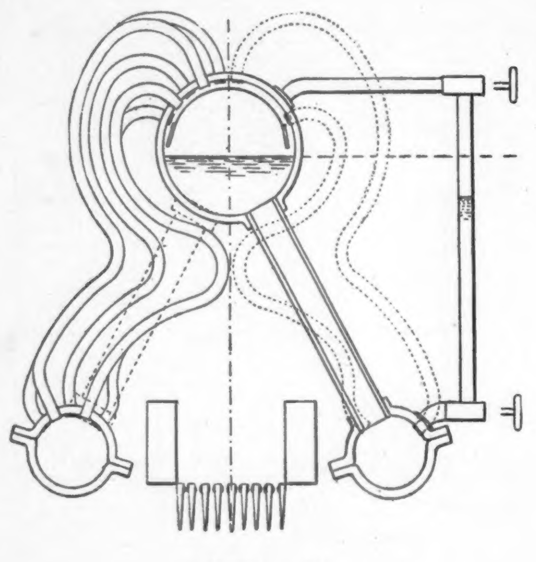


Fig. 1.

"To obtain the highest evaporative duty from a given tube service, it is necessary that the contents of the tube should consist of, as far as possible, water only; and to attain this result the steam must have the freest possible egress from the tubes, and must also be carried from them by an energetic circulation of water in a constant direction. To some of the leading features which affect these conditions I would now call your attention. Considering the boilers shown in figs. 1 and 2, if the pressure in the lower vessel—that is, at the bottom ends of the generating tubes—is due to the full depth of water in the boiler, in addition to the steam pressure, then any reduction of density in the generating tubes will all be available for causing circulation; and thus any reduction in pressure in the lower vessel, below that due to the head of water in the boiler, is a direct loss to the energy of circulation, so that variations of this pressure are of great importance. These variations can be conveniently measured by a pressure column formed of a long gauge glass connecting the steam of the upper vessel with the lower vessel. The difference of the water-level in this glass from the water-level in the upper vessel is a direct measure of any reduction of pressure in the lower vessel.

"I have made experiments, taking observations from such pressure columns fitted to the boilers shown in figs. 1 and 2, when they were working under different conditions, the rate of evaporation and steam pressure being varied for the several arrangements of boiler, which were: 1. Generating tubes delivering above water. 2. Generating tubes delivering below water. 3. Generating tubes delivering below water—without any special undertake tubes.

"The curves given in diagram 3 show graphically the results of these experiments; the falls of pressure in the lower vessel are plotted as ordinates, and rates of working as abscissæ. It will be seen that the rate of working has been taken up very high, probably more than double ordinary working, the object of doing this being to ascertain up to what rate each arrangement can be worked with safety. In the first series of curves the results recorded are obtained from the boiler, fig. 1, with the generating tubes delivering above water. It will be seen from the curve that, as the rate of working is increased, the pressure column falls slightly, and at an evaporation of 20 lbs. of water per square foot of heating surface stands at 85 per cent. of the maximum; and by halving the working pressure the results are not sensibly changed.

"The next series of curves is taken from the boiler, fig. 2, which has the same heating surface, etc., as fig. 1, but the top ends of the tubes deliver below water. It will be seen that the curves fall more rapidly than the first series, and that by halving the working pressure the pressure is distinctly reduced in the lower vessel.

"The third series was obtained from the boiler, fig. 2, by plugging up the down tubes, so that some of the generating tubes had to act as down tubes for the supply of the others, the feed-water of all being delivered into the upper vessel. In this case the character of the curve changes from the first two

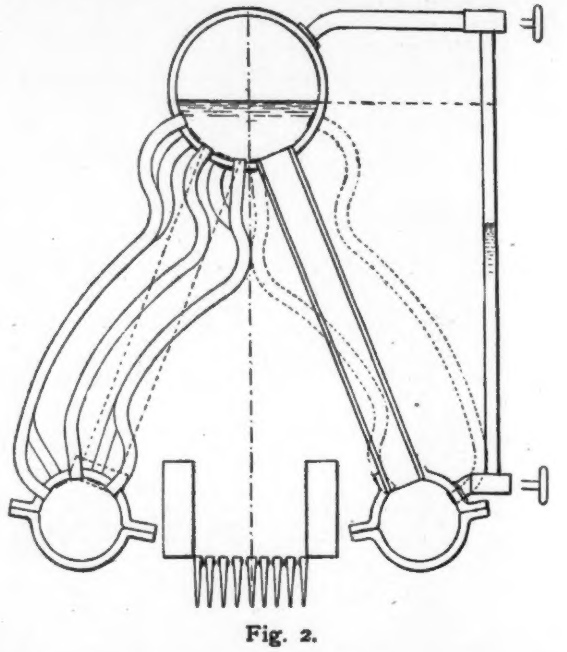


Fig. 2.

series very much. A diminution in pressure of working causes the pressure column to fall very much; in the case of the pressure being only 28.75 lbs. per square inch absolute, it fell to about 46 per cent. of the maximum. The most important point, however, apart from this low pressure, but a result of it, is that from any given pressure a critical rate of working is arrived at when the pressure begins to rise again with increased rate of working, thus showing an increased pressure in the lower vessel, caused by the steam being unable to get out at the top ends of the tubes fast enough, so comes out at the bottom ends as well. It will be seen from the curves that the lower the pressure of working the sooner this critical point is arrived at, and I found that when the evaporation was pushed beyond the critical point the tubes were not safe from overheating; but by taking the tubes intended for downtakes, and extending their upper ends above the water surface, so that water could not go down, and the steam in the lower vessel could readily get away to the separator, it was possible to increase the rate of evaporation somewhat, inasmuch as the facility for the tubes getting rid of their steam was increased.

"Contrasting the different conditions of working of the water tubes in the three series of experiments I have described, and noting what slight differences these conditions may necessitate in the design of a boiler, the nearness to success which a boiler intended for hard forcing may be, and yet fail, is clearly shown.

"In conclusion, I would submit that the absence of special down tubes limits to a great extent the amount to which a boiler can be safely forced, and shows to obtain the highest rate of working with safety and efficiency these special down

tubes must not be neglected; and still further, the tubes should deliver above water, as then the circulation, as I have previously shown, is double that when the tubes deliver below water. So that this rapid circulation is a most important condition for hard working."

CENTRIFUGAL PUMPS.*

By John Richards.

INTRODUCTORY.

The essay to follow will be a peculiar one in some respects, a technical subject dealt with empirically, and in many cases by controversion of assumed data respecting centrifugal pumps, perhaps mistakably now and then, but in all cases from observation and actual experience in designing, constructing and operating such pumps.

These pumps are a class of machines *sui generis*, that defy the mathematician, and, as an old workman once remarked to the writer, "have more tricks than a circus mule." One of these tricks is to give no external hint of the complex forces and condition set up in operating. For this reason, and for various other reasons, they have no literature to this time that has much aided those who make centrifugal pumps.

There is, perhaps, not in the whole range of organized machines any other that will not admit in greater degree of rules that have general application. Formulæ, such as exist, are ignored by the practical pump maker, who soon learns, to his cost sometimes, that computations will not supply proportions or define the working conditions required, and that he must proceed tentatively and tediously to ascertain the best forms of construction for particular uses, and for the head or pressure in each case. This statement will require some explanation.

Lying before us while writing this is 'data for constructing centrifugal pumps by M. D. Thompson, taken from Vol. XXXII, Transactions of the Institute of Civil Engineers, London, in which it is stated that an 18-in. centrifugal pump will work well with a 20-ft. lift, and a 36-in. pump will do the same with a 30-ft. lift. There is nothing in the context to explain this, and perhaps need not be. It is not explainable.

In the same connection is a table in which the diameter of the wheels or impellers is given as a measure of capacity. For example, an impeller 12 in. diameter will discharge 1,200 galls. a minute, and one 24 in. diameter 4,800 galls. a minute. These are examples of centrifugal-pump literature as it now exists, taken from Molesworth's Pocket Book, edition of 1893.

These proportions are almost without the pale of comment, and the same remark applies to a good deal besides, including a constant rule to lay out the curve of the vanes given irrespective of the head or speed, also the statement that the speed of small impellers in feet per second is $8\sqrt{H}$, and large ones $9.5\sqrt{H}$. As all these things will be referred to in remarks to follow they need not be criticised independently.

In other authorities are found tables of efficiency attained with concentric and volute chambers, giving such efficiencies as 1 to 1½; also the efficiency of vanes due to their form, varying from 20 to 40 per cent., without in either case including, or even mentioning, the head or the velocity of the impellers, but the strangest of all is in one case where the diameter of impellers is made a function of the diameter of the suction pipe or the inlet at the sides of the pump, the head, and consequently the speed of revolution, not being taken into account.

In "Hydraulic Power and Hydraulic Machinery," a recently issued work by Professor Henry Robinson, under the heading of "Centrifugal Pumps," is found the following:

"For raising large quantities of water a small height, a 'centrifugal pump' (which is practically an inverted turbine) is a very suitable form of pump. Appold constructed the first, and it has been the basis of all subsequent ones. In this form of motor it is necessary to bear in mind that the greatest efficiency can be only obtained when it is applied to work under a constant head. The calculations on which the shape and design of the motor are based show that an equally good result cannot be obtained when the head is variable. A velocity of about 5 ft. per second for the flow of the suction and discharge water is generally regarded as that which should be aimed at. The disk friction varies as the square of the diameter, and the loss due to total frictions increases as the cube of the velocity. Experiments with centrifugal pumps have established an efficiency of about 50 per cent. in the small pumps, and about 70 per cent. in the large pumps. The shape of the curved vanes of the fan materially affects the results, the best form being that in which these are bent backward."

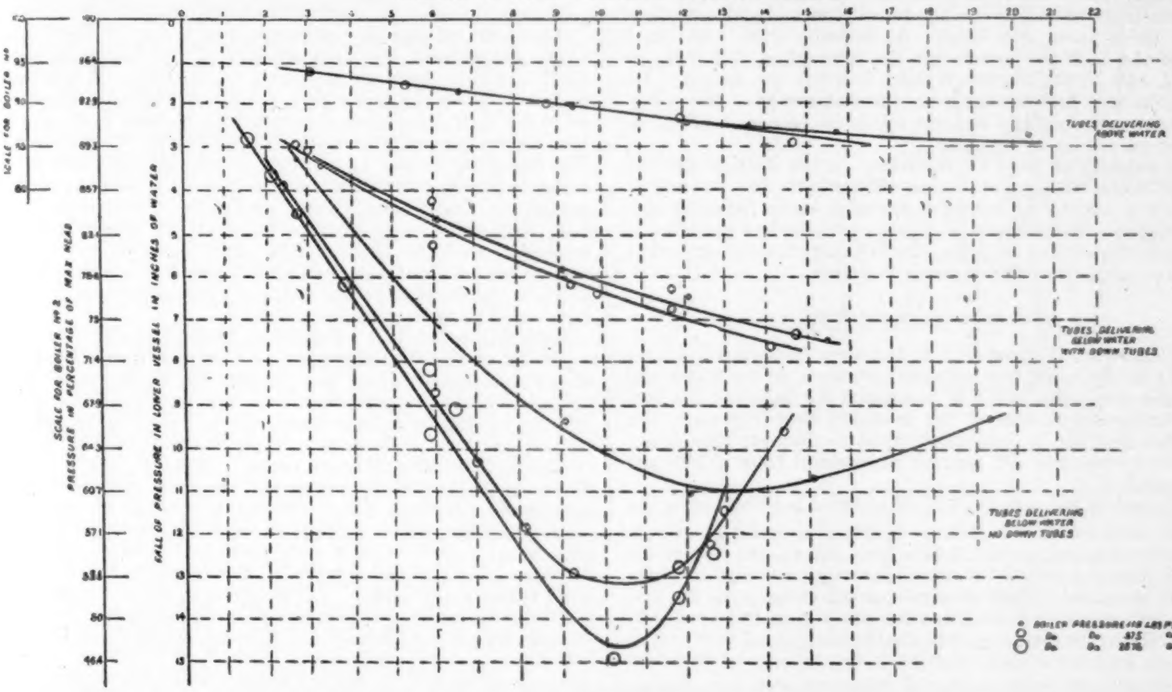


Fig. 3.

These remarks we think will confirm what has been said about the literature of centrifugal pumps. The "inverted turbine" suggests carelessness of statement. There is scarcely any analogy between a centrifugal pump and a turbine, in so far as the forces at work in the two cases. The other propositions, including the invention of centrifugal pumps by Appold, will be considered in a future place.

One other circumstance of an introductory nature requires mention here. The intention was at first to republish, with revision and extension, the subject-matter of a series of articles written in 1886 for the *Mining and Scientific Press*, San Francisco, giving such facts as could be gathered respecting the

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origin and history of centrifugal pumps. A second conclusion was that this matter would have increased interest if preceded with some explanation of these pumps, and the methods of their construction and operation for various purposes. This, as may be supposed, even in as condensed a form as possible, will greatly extend the space at first contemplated, but the importance of the subject warrants this, and even more than it is possible for the writer to include in such an essay at this time.

I.—CONSTRUCTIVE FEATURES.

In preparing designs for centrifugal pumps the first element to be considered is capacity, or the velocity and volume of water to be raised or forced. Velocity comes first, and is commonly less in the case of large pumps, where power is more considered, than for small ones. This is commonly arranged the same for both inlet and discharge ways in large pumps, and from 5 to 10 ft. per second, as the permanency of the duty may warrant. By this is meant that if only intermittent duty is required, as in irrigating and reclaiming land, there is a point where the interest on investment in the larger machinery and slower flow costs more than is gained by the avoidance of friction in larger machinery and a reduced velocity.

For this reason the velocity of flow in pump orifices is usually much increased over that in suction and delivery pipes when these latter are long. A desirable rate with small pumps of 6 to 12 in. bore is, for the inlet pipes, 5 to 6 ft. per second, and for the discharge pipes, 7 to 8 ft. per second. Between the inlet and discharge are the waterways of the pump. These are not at control and can follow no rule, as will appear further on.

The velocity or flow of the water in the suction and discharge ways of a pump being determined, the volume or capacity is next to be considered, and is easily found by simple computation expressed in gallons or cubic feet per minute. The next element to be determined is the diameter and number of revolutions of the wheel or impeller.

THE SIZE OF IMPELLERS.

The diameter of these will at first seem to depend upon the velocity of the radial flow between the vanes, so the water will make one revolution while in or around the impeller, the flow being uniform with that of the inlet and discharge ways, but here the designer is first called upon to disregard one of the laws of hydraulics and assume dimensions from a different standpoint.

The speed of the periphery of an impeller is governed by the law of acceleration for falling bodies, $V = \sqrt{2\,g\,H}$, or, expressed in feet per second, 8.025 times the square root of the head, commonly called for simplicity eight times the square root of the head. This circumferential velocity of the impellers will raise a column of water to the assumed head, but the additional pressure required for discharge or "flow" must be added, so it is common to estimate the velocity of impellers about 20 per cent. more, or $10\sqrt{H}$, which answers as a general rule, although the result is modified by the form of the vanes and the depth or width of the discharge chamber beyond the vane tips.

To proceed here by inference, or, as we may say, mathematically, the diameter of the impeller, or the number of its revolutions, as before mentioned, should depend upon the path of a particle of water through and around the impeller, and as this need not exceed 360°, or one revolution, there seems to be clear ground to proceed upon.

Assuming, for example, a head of 36 ft., then $10\sqrt{36} = 60$ ft. per second, or 3,600 ft. per minute, will be the velocity of the perimeter of the impeller, and if the pump is of 12 in. bore, and the wheel, as is common in practice, is 3 ft. in diameter, this will call for 382 revolutions per minute, which is a full limit for the endurance of the spindle bearings, in fact, is more than good practice will permit. If the diameter is made according to some rules given, twice that of the inlet pipe, then the number of revolutions would rise to 573 per minute, and the result would probably be a failure of the spindle bearings.

At the slower speed of 382 revolutions per minute for the impeller, and assuming the service flow in the pump orifices to be 7 ft. per second, or 420 ft. per minute, we find that if the water is to be carried through one revolution the radial flow will be, counting from the axis, at the rate of 573 ft. per minute, then the waterway through the impeller would be reduced about 8 per cent., and the velocity increased accordingly. Such an arrangement would cramp the inlet flow and cause obstruction to solid substances passing through the pump, so the section of the water ducts in the impeller have to be increased and the water carried through 500° to 800° of revolution, for mechanical reasons.

The discharge area at the periphery of the impellers, if made uniform with the outlet and inlet orifices of the pump, would be liable to clog, even in ordinary service, so this is usually made of double area, and the radial flow reduced to about 50 per cent. of its velocity in the inlet and discharge ways of the pump.

It will therefore be seen, unscientific as it may seem, that the diameter of the impellers of centrifugal pumps, and consequent size of casing, is based upon mechanical and operative reasons, and not on any hydraulic law. The safest way is to assume a limit of speed for the spindle-bearing surfaces not exceeding 350 ft. per minute, and from the revolutions thus obtained lay out the impeller accordingly. A good rule is to divide 1,000 by the diameter of the spindles in inches for the number of revolutions per minute; this will suit in all cases for water pumps.

The waterways of the pump, through the impeller and throat and elsewhere, must also be arranged to suit the nature of the duty to be performed. In some cases, as in dredging, for example, the velocity of the current may have to be reduced by enlargement of the throat to one-fourth what it is in the discharge nozzle or inlet to avoid danger of clogging.

PUMP CHAMBERS.

The bore or capacity, diameter, and speed of revolutions being determined, the next element is the casing or pump shell, and here again we meet with complexity. It was mentioned that one authority gave for volute shells an advantage of 20 per cent. in efficiency, which may be true, and less than true in some cases, but will not apply at all in other cases. The impelling power in centrifugal pumping consists of two separate forces, centrifugal force, and what is called tangential energy, or "mechanical push," due to the action of the vanes and force of discharge from the impeller, but these forces vary relatively with the head, and in such degree as to supplant each other at high and low heads, and on this circumstance depends the value of volute or spiral pump chambers or "casing," as they are commonly called.

Referring to fig. 1, it will be seen that the casing is in effect a portion of the discharge pipe, and may be thus considered, so a constant velocity of flow therein can be assumed for all heads. This being constant, and the tangential energy or velocity of discharge from the impeller being as the square root of the head, it is easy to see how rapidly the conditions change as these velocities are varied relatively. At a head of 40 ft. the tangential discharge will be 63 ft. per second, impinging on a body of water flowing at a tenth of this rate. This, expressed mathematically in terms of *vis viva* momentum and velocity, will show a considerable impulsive effect, for example: If M is the weight of the impinging water, and V its velocity; M' and V' the weight and velocity respectively of the water in the pump shell, and the lines of force are coincident, but the directions of flow are opposite, then

$$\frac{M\,M'}{M + M'}\,(V + V')^2 = \text{the inductive effect of the tangential}$$

energy. As a matter of fact, however, no such result takes place in practice; the angle of impingement is uncertain, depending on several circumstances, such as the velocity of radial flow, or width and form of the impeller, also the form of the vanes.

The thin stratum of water discharged at e, fig. 2, into the main discharge at a velocity ten times as great, disturbs and breaks up the solidity or normal flow in the discharge way, and, as experience proves, produces no useful effect that need be considered in designing pumps to operate against heads exceeding 40 to 50 ft. This statement, the writer feels called upon to explain, is based upon experience in dealing with heads from 40 to 100 ft. in a large number of cases where tangential energy was provided for, and in other cases where it was disregarded—that is, concentric and volute casing gave the same result. This may be called one extreme.

Proceeding now to the other extreme, for low heads of 2 to 5 ft., there is found a wholly different set of conditions, modifying the form of the pump chambers, and various other features of a constructive nature. For constant low heads, such as occur frequently in draining operations, there is a complete change of conditions, so much so that centrifugal force as an impelling force may be disregarded.

For low heads the velocity of the impeller or the vanes need not follow the rules before laid down. For heads from 2 to 5 ft. it will be as follows: $10\sqrt{2} = 14$ ft.; $10\sqrt{3} = 17.3$ ft.; $10\sqrt{4} = 20$ ft., and $10\sqrt{5} = 22.3$ ft. per second. With these low heads it is not necessary or expedient to limit the discharge flow to 8 ft. per second. This could be raised to correspond

with the velocities above noted, but should not exceed 12 ft. A pump under these conditions becomes an impact or "pushing" machine, corresponding to and almost identical with what is called a scroll impact water wheel reversed, the action comparable also to common water-lifting wheels, such as are employed at New Orleans and in Europe generally, for low and nearly invariable heads.

There is also the problem whether there should be any free or discharge space beyond the tips of the vanes except a discharge-way carried off tangentially, as in fig. 3. In this case, taken from actual practice, for a head of 3½ ft., the centrifugal action was almost entirely ignored, the impeller fitting close in a concentric chamber and the blades curved forward instead of backward. The inlet *a* was 50 per cent. greater in area than the outlet *e*, and the section of the latter, as well as that of the main chamber, rectangular. The pumps were vertical, submerged, and arranged to work through a bulkhead, *c*, no valves or pipes being required. The result fully confirmed the hypothetical reasoning on which the scheme was based—namely: That under the circumstances the circumferential velocity, or the vane velocity, would correspond very nearly to the discharge flow.

The writer has employed the same method with success for river dredging pumps where the head was but little, being only the difference between the river's surface and the point of discharge. The advantages gained by such construction for pumping stones or other solids are very important, and more than compensate for any loss of efficiency, such as may occur.

The impact of the vanes against bowlders or stones is avoided when the vanes are moving at nearly the same speed as the discharge flow, and solid substances are not thrown out violently against the casing as in the case of a common centrifugal pump. There is also an avoidance of clogging, which is almost sure to occur with a volute chamber, by solids becoming lodged or wedged in between the vanes and the case; also much less of the abrasive effect of gravel or sand discharged radially that with a common pump will cut through the shell in a week or two of continuous service. Here we have another wide infraction of all rules laid down for pumps of this class, a disregard of nearly all the features that apply to water pumps for heads of 10 ft. or more.

The efficiency of a pump made in the manner shown in fig. 3, or with a concentric chamber, the vanes curved either forward or backward as the relation between their speed and that of the discharge flow may demand, is from 40 to 50 per cent., as nearly as observations in practice can determine.

VOLUTE PUMP CHAMBERS.

The next element to be considered in centrifugal pump construction is the section and shape of a volute chamber when the conditions of service demand that form—that is, for heads from 5 to 40 ft. or perhaps 50 ft.

A theoretical form of the volute or spiral casing should, to maintain uniform velocity of the discharge water, begin at nothing, and gradually expand to the discharge bore for a finish, but here again we are compelled to abandon the theoretical road because of certain operating conditions.

Referring to fig. 4, which is a diagram showing a theoretical volute chamber such as is employed by a good many makers of such pumps, it seems correct, but there is no provision for radial or outward flow for some distance at *a*, consequently the water contained and flowing between the vanes is checked in its course once on each revolution, while passing this point.

The writer made this mistake in 1883 in designing a pump to raise the surface drainage in the City of Sacramento. The pump is yet in use, giving a fair efficiency after ten years of service, but it developed a queer phenomenon that remained for some time a problem for which no clew could be found. The pump, when started, set up a series of rhythmic pulsations, causing vibration of the timber supports on which it stood that made it disagreeable to stand near the machinery. The first impression was that the impeller was not balanced, but it was soon discovered that the frequency of the vibrations or pulsations did not correspond to the revolutions, but to the revolutions multiplied into the number of vanes, and it will be no disparagement to admit that the real cause was not understood for some years later when other experiments proved where the difficulty lay.

Since that time the writer has in all designs for water-raising pumps of this class begun the volute at *n*, fig. 1, with one-fourth to one-sixth the area or section it has at the discharge *a*, thereby sacrificing a considerable portion of the tangential energy, and causing an accelerated flow in the casing. This necessity for space in the discharge chamber at *n*, and the throat or cut-off plate *s*, is well understood. Messrs. Gwynne, of London, have always arranged their pump chambers in this manner. The cut-off or baffling plate *s* will be considered in a future place.

The nearness with which the vanes approach the volute chamber, or the radial depth at *e*, fig. 2, does not seem to be a matter of importance in a pump's operation, but regulates a constructive matter of some importance—namely, whether the pump chamber has to be parted through its axis to insert the impeller, or whether this be done through removable side plates, as in figs. 1 and 2.

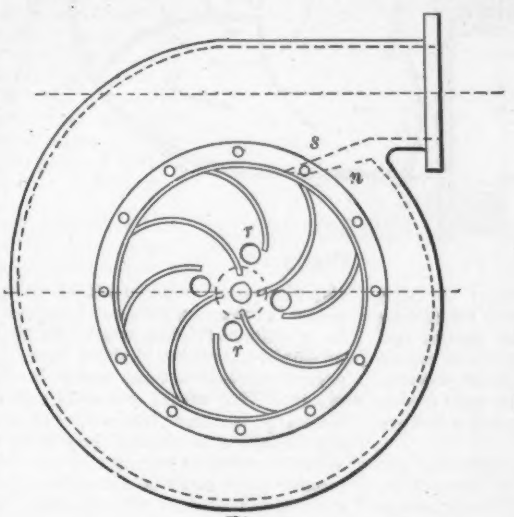


Fig. 1.

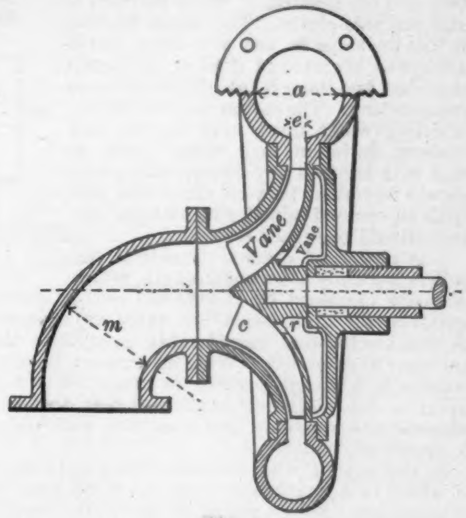


Fig. 2.

In the latter case a pump chamber can be cast in one piece, and erected so the discharge will be at any angle, the side plates, inlet and spindle bearings remaining undisturbed. This method has been a characteristic of the practice of Messrs. J. & H. Gwynne, above referred to, and is certainly desirable in nearly all cases, the exception being when there is no room at the side to remove the impeller, and when the shaft must pass through the pump, as in the case of circulating pumps for condensing water on board ships. Convenience and symmetry favor the solid volute casing with removable side plates.

THE VANE CHAMBER.

The tapering form given to these chambers is an attempt to maintain uniform area and consequent velocity of the water in its radial flow from the inlet. This is a rule of hydraulics, the violation of which causes a considerable loss of power if not observed, and brings us again to a point where centrifugal pump construction must diverge from theory.

Referring back to fig. 2, and supposing the dimension *m* to be 30 in., the area will be 707 in., and to maintain a uniform velocity of the water this section must be maintained out to and through the throat *e*. For an impeller 60 in. in diameter the perimeter will be 188.4 in.; this divided into 707.8 gives a width of 3.76 in., which is too narrow if any kind of débris, such as grass, roots, or driftwood, is to be passed through the pump. This difficulty increases with the diameter of the impellers until at a head of 50 ft. the area should be double that of the inlet *m*, and for higher heads in proportion, especially when encased impellers are employed, as will be explained in a future place.

The curves in the water-ways in fig. 2 are supposed to be as perfect as can be attained, and are taken from designs made by the writer in 1886, for the Westinghouse Machine Company, of Pittsburgh, Pa., also for Messrs. W. T. Garratt & Co., of San Francisco.

IMPELLERS OR WHEELS.

These are made in three forms: with open vanes only; with

a disk or side plate open on one side, as in figs. 1 and 2 ; and encased or with two side plates, as in fig. 5. There is also a type having hollow arms that set the water around them in revolution, and thus avoid circulation back through the inlet, as will be further explained in future.

The function of the impeller being to set the water in revolution, its construction in respect to efficiency is not a matter of much importance, but there is a vast difference in the conditions under which pumps operate with open and encased impellers. Leaving out for the present the plate form with vanes on one side, and considering the open and encased forms only, the difference is one that would never be supposed from inference.

With the open form the whole mass of water within the pump is set in revolution, and the surface friction is between this mass of water and the side plates.

With the encased form the water within the impeller is set in revolution, and the surface friction is between its outer surface and the stratum of water between it and the side plates. The water friction is just the same in the two cases, and is always as the area of sides of the pump chamber, but there is this difference as to construction. The surface over which the whirling water flows must be true and without deviation in a radial plane, so that with an open impeller the side plates should be turned true on the inside, and with an encased impeller its exterior surface should be turned true.

The object of encased wheels or impellers is mainly to secure strength, which is vastly increased by this form, and is necessary at high speeds or for high heads, but there are operating conditions to provide for that considerably complicate the method and are open to objection. With an encased impeller the whole interior of a pump chamber is subjected to a static pressure equal to the discharge head, and this demands heavy side plates of ribbed section, and even then with high heads flexure is almost unavoidable.

In the case of what are called pit pumps in California, one of which is shown in section at fig. 5, the head is often 60 ft. or more, sometimes reaching 80 and 90 ft. At 60 ft. the pressure is about 26 lbs. per square inch. The impellers are 30 in. or more in diameter, and the sides of the pump case, including the discharge volute, when that form is employed, will make up a diameter of 42 in., and area of 1,385 in., sustaining under a head of 60 ft. a static pressure of 36,000 lbs., or 18 tons of internal strain on each side, so that a pump chamber not well ribbed will expand under such a force and be broken. At lower heads, and with larger pumps, this difficulty is less, but remains a factor to be carefully taken into account in designing centrifugal pumps of all kinds.

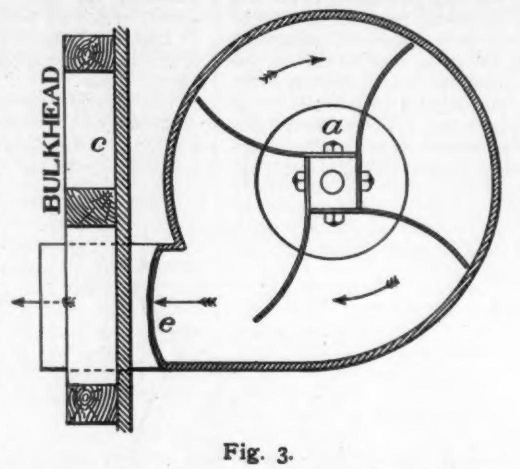


Fig. 3.

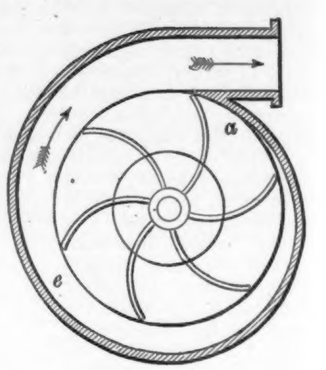


Fig. 4.

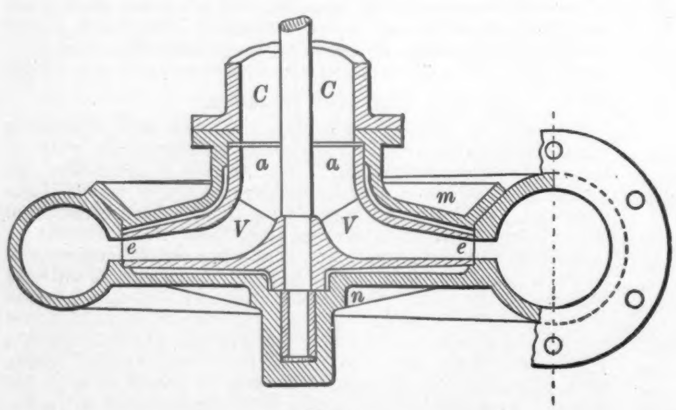


Fig. 5.

If the impeller is open the pressure on the side plates is in a large degree removed, because at the center of the pump, or over the inlet area, there is not only no internal pressure, but a negative or inward pressure, a partial vacuum, which gradually, and in some ratio not understood, changes to outward pressure, from the inlet to the discharge chamber. Theoretically such change of pressure would be a constant increase, but in an experiment made some years ago, holes were drilled through side plates at distances of three inches or so from the inlet pipe outward, and no water was discharged until it reached almost to the periphery of the impeller, which was 40 in. in diameter.

In another case a small pump having an impeller 20 in. in diameter was sold to a miner to be carried into the mountains and employed to raise water 110 ft. He was informed that the side plates were only ⅜ in. thick, and the pump would certainly burst. He replied laconically that " the pump was as heavy as he wanted to transport on a mule, and if it burst he could mend it." A letter from him informed the maker that the pump was " all right."

This difference in internal pressure between open and encased impellers is of course modified by revolution of the stratum of water between an encased impeller and the side plates, and as no additional friction would result it would be an improvement no doubt to employ shallow vanes on the outside of such impellers, so as to set the water in revolution against the side plates. This would not only relieve the latter of most of the discharge pressure, but would meet and prevent what is a serious objection to encased impellers, that of loss by circulation. With an encased impeller of any kind having no vanes on the outside there must be a running joint around the inlet nozzle, maintained against the discharge pressure. This can be explained by referring to fig. 5.

Supposing the inlet *a a* to sustain a negative or inward pressure due to a suction head of 20 ft., or 8.6 lbs. per inch, and the discharge throat of the impeller *e* subjected to a discharge pressure of 40 ft., or 16.2 lbs. per inch, then as no water joint can be maintained around the periphery of the impeller, the space at its sides, above and below, will be filled at this same pressure of 16.2 lbs., which, if added to the negative or inward pressure of 8.6 lbs., produces a force of 24.8 lbs. per inch, tending to circulate the water through the running joint at the inlet nozzle of the impeller. Whatever water can pass here, and it is commonly a good deal, is only circulated in the pump, and represents lost work.

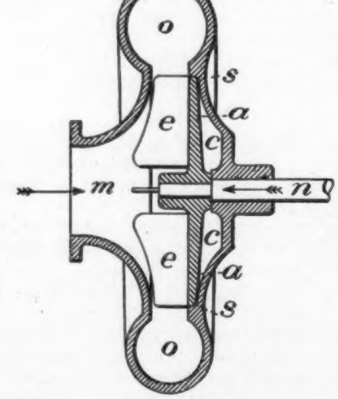


Fig. 6.

The writer in his practice has usually employed several ledges or collars and grooves to obstruct such flow, and ended up with the abandonment of encased impellers, except when a fibrous packing around the nozzle could be employed. With clear water, where no grit or sand is present, these running joints can be maintained tolerably close, but this loss by circulation is always a matter of uncertainty, and not observable or even ascertainable after a pump is once erected except by an obvious loss of efficiency. Unquestionably the best way is to have vanes on the outside of an encased impeller, so as to cause revolution of the water there. As before remarked, there is no difference between the friction of the water against the side plates of the pump and the friction against the sides of the impeller. It is the same thing when the surfaces are alike in the two cases.

BALANCING CENTRIFUGAL PUMPS.

We have now reached the most interesting problem in centrifugal pump construction—that of balancing the lateral thrust upon the impellers. It is a matter that modifies nearly all the constructive features of practice, and is, by any fair standard of comparison, one of the most intricate problems in hydraulic apparatus.

Some years ago, during some experiments at the University of California, Professor F. G. Hesse discovered the force developed on disks having different degrees of centrifugal action on each side, and prepared an essay on what he called a "hydraulic step" to resist weight or thrust, explaining the forces by formulæ. This paper was widely circulated and remarked upon by Professor Unwin and others. At the same time, however, this method of balancing weight and thrust was in practical use in California, for sustaining the weight of shafts in pits, but without Professor Hesse's knowledge, having been discovered in practical working.

To illustrate the nature and amount of lateral thrust on the disk form of impellers for pumps, and referring to the diagram, fig. 6, suppose the inlet at *m* to be 12 in. diameter, and have an area of 113 in., and that the head to be operated against is 40 ft., also that the impeller disk *a* on the shaft *n* is 36 in. in diameter and provided on one side with a series of vanes *e*. The pressure in the discharge chamber will be 17.2 lbs. per inch static, or in operating at least 18 lbs. per inch.

To find the unbalanced pressure and inward pull on the shaft *n*, the difference of pressure on the two sides of the plate *a* is not an easy matter. On the front or vane side there is the impingement of the entering water against the plate, which if curved, as in fig. 2, would amount to but little, certainly not more than 100 lbs. for a flow of 6 to 8 ft. a second.

There is also the increasing outward pressure from the inlet outward, due to centrifugal force, but, as remarked in a previous place, the amount of this force is not known, but it certainly does not exceed one fourth of the exposed area multiplied into the discharge pressure. Deducting the area of the inlet leaves 593 in. of area for the disk on this side, which, if multiplied by one fourth the discharge pressure, gives 2,668 lbs., and, adding for impingement, 2768.5 lbs. for the front or vane side.

On the rear side of the plate *a* toward the chamber *c c*, if there is no rotation of the water, there is, by reason of the water passing over the rim at *s*, a pressure equal to the discharge over the whole surface, except the area of the shaft *n*. This pressure or thrust will be $706.8 \times 18 = 12722.4$ lbs., or, less the area of a shaft 3 in. diameter, 12,596 lbs., from which must be deducted the counterbalancing pressure of 2768.5 lbs. on the front side, leaving unbalanced the enormous force of 9953.9 lbs. This is an extreme case, assumed for the purpose of illustration. No one at all acquainted with the matter would think of designing a pump in this manner, unless this lateral thrust was required for some purpose. It cannot be safely resisted by thrust collars of any kind, even when these are under water.

It is not an easy matter to determine when an impell r is not balanced, or the amount of lateral thrust upon it. It must be remembered, however, that it is always in proportion to the field of water rotation on the two sides, and this naturally leads to the conclusion that a pump should have an inlet at each side. This would be correct if it were not possible to balance the centrifugal action on each side without double inlets, and in this manner secure not only complete equilibrium, but also attain other important advantages of both construction and operation. It is not always desirable to balance centrifugal pumps; on the contrary, the lateral thrust on the impellers becomes essential in some cases, as will be explained further on.

In deep pits, such as are common in the irrigated districts of California, the pumps have to be set 40 to 50 ft. below the surface in order to be within suction distance of the water. Such pumps, from 4 to 6 in. bore, are driven by vertical shafts extending up to the surface where the driving power is applied. The shafts are commonly 2¼ in. diameter, and weigh with the couplings and fittings at least 20 lbs. per foot, or for 50 ft. 1,000 lbs. These shafts with the impeller of the pump, to operate well, must be balanced by water thrust, which in the case of disk impellers is provided in a very ingenious manner, shown in fig. 7.

The water enters on the top around the shaft *m*. The impeller disk *a* is provided with working vanes *e* on top, and balancing vanes *c* on the bottom, the latter enough shorter than the top ones to produce a modified centrifugal action beneath the plate, and this difference when adjusted is made to sustain the weight of the shaft *m* and all of its connected parts, weighing from 800 to 1,600 lbs. If the up thrust or balancing is not enough the impeller is taken out, and the ends of the bottom vanes trimmed off at *n* until an equilibrium is obtained. The bottom vanes *c* are commonly one-third shorter than the top ones *e* when the disks are 24 to 30 in. diameter, and it is surprising to see what an effect is produced by cutting off even half an inch from the ends of the vanes at *n*. This method of balancing disk impellers for centrifugal pumps is also applied to encased impellers, as in the case of pumps illustrated in fig. 5, and is shown in its most complete form applied to a horizontal pump in fig. 2.

It will be noticed there are vanes on both sides of the disk, those on the back being to set up there the same centrifugal action and force that exists on the front or working side. It will also be noticed that the back or balancing vanes are a lit-

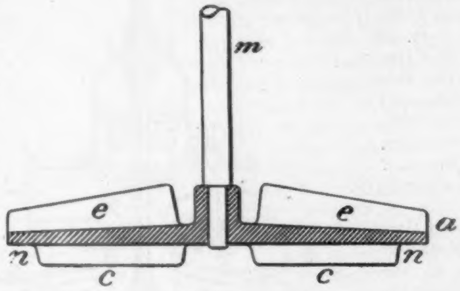


Fig. 7.

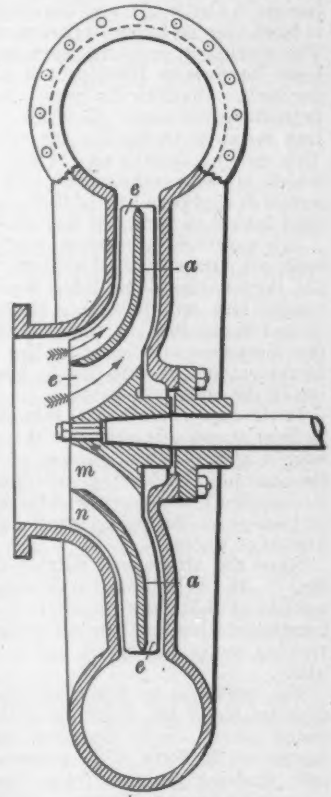


Fig. 8.

tle shorter than the front ones, commonly from ⅛ in. to ¼ in. for pumps to 10 in. bore. This slight difference in the length of the vanes, or the diameter over their tips, permits a slight excess of pressure on the front or working side,* and consequently a slow flow of water over the periphery of the disk into the chamber behind; some small holes *r* being provided for circulation. If the rear or balancing vanes were as long as the main ones, and centrifugal action the same on each side, the rear chamber would become partially or wholly filled with air, and the equilibrium destroyed.

This method of balancing the lateral thrust on disk impellers was first applied by the writer in 1886, and is believed to be more reliable than double inlets. It may be described as providing for equal centrifugal action on each side of the plate or disk, but performing the whole work of propulsion on one side.

Attention is called to the curves and course of the water through the pump shown in fig. 2. Such easy curves are not attainable in double-inlet pumps, but very nearly so in another method of balancing plate or disk impellers next to be explained.

This method, shown in fig. 8, is one of recent invention, and apparently the most complete that has been discovered. It consists, as can be seen, in receiving the water at one side of the pump, thereby attaining the several advantages of that method already pointed out, and has the same balancing effect that is attained by a double inlet, but avoids the short curves and consequent obstruction that seems inseparable from the double-inlet method; also avoids placing the shaft or spindle through the inlet pipe or pipes. The water passes in equal volume on each side of a disk or web, *a*, the outer and inner annulus *m* and *n* being equal in area. The curves are easy and the construction strong, because the disk or web *a* acts as a continuous brace between the vanes *e*.

The distinction from the method of balancing last described is not only in the manner of operating, but also in the construction of the impeller itself. In the present case the vanes rise out of the boss or hub the same as with an open impeller,

the disk a forming only a web or brace for the vanes. In fig. 2 the disk itself is the main member, the vanes being set thereon in the form of ribs.

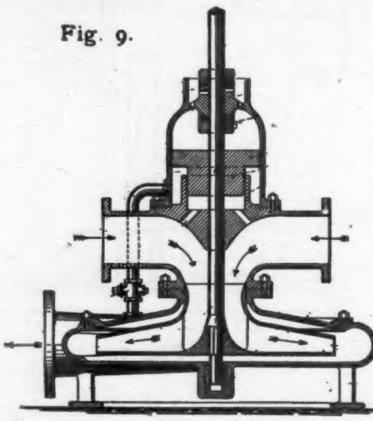
BALANCING ENCASED IMPELLERS.

When the impellers of centrifugal pumps are encased, as shown in fig. 5, the compensation of lateral thrust is an easier problem in one respect, and a much more difficult one in another respect. The unbalanced area is only that of the inlet a less the area of the driving shaft's section, and the up-thrust in this case is as these areas taken with the discharge pressure, but there is the difficulty in all forms of encased impellers of maintaining running joints that permit waste by circulation.

Supposing the pump shown in fig. 5, which is repeated here for convenience of reference, to be constructed to operate against a head of 75 ft.; to be of 6 in. bore, and have an impeller 30 in. in diameter, and the weight of the shaft and other parts to be balanced 1,500 lbs. These proportions follow average practice for pit pumps in California, and the type as drawn is from designs by the writer made in 1886. The discharge pressure, counting 5 ft. of head for flow or friction, will be 34.4 lbs. per inch. Dividing the gravity load by this pressure gives about 35 in. of unbalanced area required to sustain the vertical load. This calls for an inlet area 11.2 in. diameter, which, taken over the outside of the impeller nozzle at a, gives a bore of $9\frac{1}{2}$ in., an average inlet for a 6-in. pump of this kind.

It is a circumstance worthy of note that with pit pumps of the kind here illustrated the thrust due to an inlet nozzle of the proper size will balance a shaft of the required dimensions to transmit the power, the increment of weight for the shaft and increment of pressure due to head following in the same proportion.

Fig. 9.



In the case of horizontal pumps with encased impellers, and an inlet at one side only, the thrust cannot be compensated by weight as in vertical pumps, and is attained in several ways; for example: by leaving the center around the shaft open, by a balancing plate opposite to the inlet, or by revolving hydraulic pistons on the pump shaft subjected to pressure from the discharge water.

Since the above was written there has been received from Mr. G. W. Price, of San Francisco, some particulars of a method of balancing impellers by means of pistons, as above mentioned, that has the advantage of ready adjustment for varying heads and speed, and is applicable to pumps of any kind.

The drawings in figs. 9 and 10 are taken from the patent specification of Mr. Price, fig. 9 showing a balancing or thrust piston placed above the pump, and in fig. 10 placed beneath the pump, the force of the pistons being upward in both cases, and receiving pressure from the discharge-way by means of connecting pipes as shown. As there is unavoidably a leak of water around these pistons, it follows that the pressure on them can be regulated by adjustable cocks in the supply pipes.

In fig. 9 the piston is compound, receiving pressure from the discharge way on an annulus, and a counter-force for adjustment from the suction acting on the central piston. As, however, pistons thus mounted on the pump spindle and fitting in fixed cylinders are subject to wear, Mr. Price has adopted a "floating" cylinder for the balancing piston, as shown in fig. 11, which is a vertical section through the main bearing and balancing piston as now applied to a number of pumps by the San Francisco Tool Company. In this case it will be seen that the balancing piston fits into a short cylinder capable of lateral movement in case the pump spindle and piston do not run true. The pipe below connects to the pump discharge, and the one above carries off waste water that passes the piston and does not find its way out through the spindle bearing, which is in this manner flooded with water.

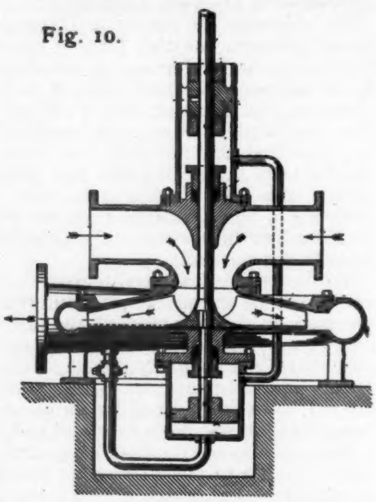
In pumps having encased impellers there must always be, as before remarked, a good deal of loss by reason of water escaping or circulating around inlet nozzles. Whatever escapes over the periphery of the impeller flows back to the inlet and is forced through there with the whole pressure due to the discharge head.

The safest way is to place shallow vanes on the exterior sides of the impellers, and set up centrifugal action against the sideplates of the pump. This will prevent back flow and circulation without any loss whatever if the side plates are true on the inside. An encased impeller of any form must either set the water in revolution at its sides, or else have running joints to maintain against back flow and circulation. This the writer knows is not a commonly accepted fact, or understood by makers of centrifugal pumps, but accounts, no doubt, for the very uniform practice in Europe of employing open or disk impellers. Balancing by double inlets will be noticed in a future place.

THE FORM OF VANES.

There has been frequent complaint of the failure to derive useful facts, or suggestion even, from the literature such as exists on the subject of centrifugal pumps. Such complaint must continue. In a work on pumps, now lying at hand, there is a table to show the increased efficiency attained by Appold with curved vanes. "These experiments of Appold," the author remarks, "showed that the efficiency of a pump mainly depends on the form of the blades of the fan." A table shows that radial flat vanes gave an efficiency of 24 per cent., angular

Fig. 10.



flat vanes 43 per cent., and curved vanes 65 per cent., the head being 18 ft.

It is hard to conceive what the circumstances were under which such results were obtained, unless it was within what may be called the flow limit. For example, a certain number of revolutions will raise the water to a given head, and 10 to 15 per cent. of added speed will cause a normal flow. The form of the vanes may have a good deal to do with this in so far as modifying speed owing to the friction of the vane tips and some other causes. The results stated must have been

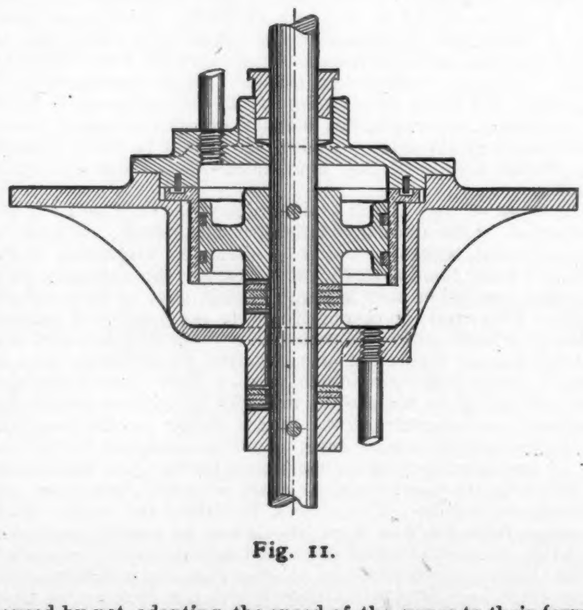


Fig. 11.

caused by not adapting the speed of the vanes to their form, otherwise there is no alternative but to call them nonsense.

This Appold experiment, and some others of the kind as well, give wrong inferences to those not able to understand the nature of forces at work, and have led to a widespread opinion that the form of the vanes is a very important matter,

whereas experience, as well as rational inference and analysis, must show that aside from the dragging friction of the vane tips their form is in common designs a matter of no consequence, or of little consequence.

In a pump operating under heads from 10 to 50 ft., where the tangential energy is a considerable factor in the effect, the vanes should conform as nearly as possible to the flow of water from the center to the periphery of the impeller, but divergence from this is, as before said, of little consequence.

The function of the vanes is to set the water in revolution, and at heads exceeding 40 ft., is but little more; the most important matter being the drag or friction of their tips on the discharge water in the pump chamber beyond the vanes. To make this understood it will be necessary to again refer to the velocities of the impeller and discharge water around it. The discharge flow is constant, and arranged at from 5 to 10 ft. per second, commonly about 8 ft. At a head of 50 ft. the velocity of the impeller will be about 50 ft. per second, or compared to the discharge flow, more than six times as great, so the tips of the vanes in every 50 ft. of movement must drag 40 ft. over the discharge water. This friction is a frequent source of loss in centrifugal pumps, and in one experiment tried by the writer showed that 25 per cent. of the power applied was consumed by retardation thus caused.

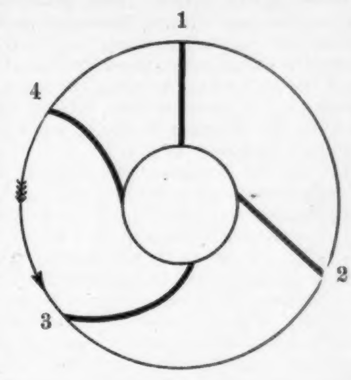


Fig. 12.

This is a reason for reducing the dimension e in fig. 2 to its lowest limits, narrowing the tips of the vanes and reducing the friction accordingly, but the point to be presented here is that as the head and velocity of the impeller increases, the vanes should be narrower at their tips and terminate more tangentially. The tips are, in fact, all that need be considered. These should change from a curve forward for low heads, as shown in fig. 3, to a true tangent, or as nearly that as possible for heads of 40 ft. or more.

To show the absurdity of imputing efficiency to a form of impeller vanes, one need go no further than the practice of Messrs. J. & H. Gwynne, of London, and of Mr Charles Brown, of Sulzer Bros., Winterthur, Switzerland. Drawings of the vanes designed by Mr. Brown, shown in fig. 12, are taken from a communication by him to *Engineering*, London, about eight years ago, and which we reproduce as follows:

To the Editor of Engineering:

Sir: The explanation given by your correspondent in No. 1,602 of the reason why the circumferential velocity of centrifugal pumps does not need to attain the value $\sqrt{2\,g\,h}$ may be one reason, but not the only one. About 1856 I carried out a series of experiments to determine the best forms and proportions of centrifugal pumps, and found that the form of the blades had a very great influence on the circumferential speed required. The annexed sketch, fig. 12, shows the forms of vanes experimented on; the total lift was in all cases 45 ft., the inner and the outer diameters of the disks as 1 and 3. To hold the water at this height, but without any discharge:

No. 1 required just $\sqrt{2\,g\,h}$.
No. 2 " considerably more.
No. 3 " still more.
No. 4 " $0.82 \times \sqrt{2\,g\,h}$.

No. 4 form was the best in every respect, and I continued to use it from the time the experiments were made to the present day.

C. Brown.

The first clause of this communication furnishes the secret of the Appold tables before referred to, and the whole indicates the value that can be placed on the form of vanes. One would be at a loss to refer to any higher authority than the able engineer above quoted, and to suppose that Messrs. Sulzer Bros., one of the most eminent firms in the world, would construct centrifugal pumps of low efficiency is not supposable at all.

The writer in his own practice has not made experiments to determine the efficiency and speed resulting from vanes of different forms, and has never considered it necessary to do so. It is one thing in centrifugal pump construction that seems to be within easy and rational analysis. The main thing, and that which has led to the many absurd statements, is the change required in circumferential velocity by the form of the vanes and the effect of dragging action on the discharge water by vanes not terminating in a proper shape where pumps are to operate against high heads.

CUT-OFF OR BAFFLING VANES.

By this term is meant the web or vane shows at s in fig. 1. These have also been set up as an important element governing the efficiency of centrifugal pumps, in fact, almost everything has been so considered except the paint on the outside, and the wonder is that this has not been included among the factors relating to pump performance.

The value of these cut-off plates, which in the Parson's experiments showed an effect equal to one third of the duty, is sufficiently indicated by the fact that one of the principal makers on this coast, who has constructed a great many successful pumps of all sizes, discards this cut-off vane altogether. Like the form of vanes it is one thing that admits of rational treatment, in so far that such cut-off plates can do no harm. Tangential energy, which these plates or throats are supposed to intercept and direct, does not take place at the point of discharge any more than at other points around the impeller, and the main function is to propel the "slip" between the impeller and discharge water to take place in a line close around the periphery, instead of in a volute path.

As has been frequently pointed out, the circumferential velocity of an impeller is much greater than that of the discharge water around the impeller. At a head of 25 ft. this difference is as one to five, or thereabout, and the "slipping" velocity is four-fifths that of the impeller. The cut-off vanes determine the situation radially of this line of slip, and whether it takes place at the tip of the blades in one circle, or whether it takes place in what may be called volute strata, between the impeller and discharge water, can only be a matter of immaterial difference. It is best to employ such vanes, for the following reasons: It meets common opinion as to the best form of construction. It can do no harm, and makes a strong tie or connection between the side plates at that point. The following circumstance is the nearest to decisive experiment that can be referred to.

The writer in 1885 designed for a San Francisco firm a dredging pump to be employed in lifting silt from the bay and sending it ashore in long pipes. The pump casing was of rectangular section around the impeller, volute in form and terminated at the discharge with a throat or passage of 6 in. clear of the vanes. The engineer of the firm insisted on having a cut-off plate, which was made of steel ½ in. thick, and set in at a proper angle, and to clear the vanes by ½ in. The pump was arranged with an open gauge pipe 16 ft. high, by means of which the discharge friction head could be observed with precision. The man in charge of the machinery was informed that the throat piece or cut-off would probably "go out" as soon as a bowlder or some scrap iron went through the pump, and in that case he was to observe the speed, friction head, and any change in the operation of the pump.

The dredging operations were being carried on in a place where a great deal of iron scrap had been unloaded from vessels, and it was but a short time when the cut-off throat was carried away, and sent out in the shore pipes. The man in charge, a good mechanic, and now a member of a well-known firm of hydraulic engineers in San Francisco, reported that no change could be detected in any way when the throat piece was knocked out, and he preferred having no obstruction of the kind in the pump again.

DOUBLE INLET PUMPS.

In treating upon the subject of balancing the impellers of centrifugal pumps, double inlets were not included among the means by which this could be accomplished, because this plan of construction involves a good deal besides balancing. There are a great many among both makers and users of such pumps who think there is no other way to operate an impeller in equilibrium except to make it symmetrical on each side of a pump, and provide a forked suction pipe with an inlet at each side. This opinion, which is after all not to be wondered at when the complexity of this balancing matter is considered, has been the cause, no doubt, of pumps being made with double inlets, against all the objections, mechanical and other, that applies to this system.

The objections to double or forked inlets are: 1. The impossibility of securing easy entering curves. 2. Inconvenience of access and expense of fitting. 3. The spindles passing through and obstructing the inlet pipes. 4. Inaccessibility of the suction pipe by reason of its being under the pump. 5. Reducing the inlet areas by dividing them into two parts with a sharp ledge to catch obstructions. 6. Preventing the discharge case from being set at various angles independent of

the suction pipes. To these objections can be added general complication and expense not required. In land drainage operations on the Pacific Coast, and presumably everywhere, double-inlet pumps are liable to obstruction by tule roots, bean straw, weeds and other kinds of débris that is unavoidably carried into the sumps.

In the case of double-inlet pumps where the suction pipes are separate, and constitute framing on which the pump chamber is supported, there is a considerable saving of material and several of the objections before named do not apply. There is the advantage for low heads of making the impeller much smaller in diameter, and this permits smaller dimensions in all parts, the general dimensions of centrifugal pumps being approximately as the square of the diameter of the fans or impellers.

As to balancing by a double inlet, this applies only to horizontal pumps, and, as has been explained, can be attained in other ways than by double inlets, at less expense, with easier curves and a more symmetrical construction.

CENTRIFUGAL DREDGING PUMPS.

One of the most successful applications of centrifugal pumps has been for dredging purposes, raising and impelling silt, sand and gravel from the bottom of rivers and harbors. This work has, to a great extent, been done with what may be called water pumps, such as have been heretofore described, but for successful working a very different type is required.

The casing should be rectangular so as to avoid to a considerable extent the friction of tenacious material, and to distribute the impingement from the impeller over a larger area, also to permit a detachable lining that is easily replaced. As an angular section for the pump chamber calls for an impeller of parallel width, there is, of course, some loss of efficiency, because of the change of velocity from the inlet to the discharge chamber, but in dredging, efficiency is not the first thing to be considered in designing centrifugal pumps. The main thing is endurance against accident and wear. The pump itself is but one element among a number that make up a dredging plant, and the main point is to keep all in constant operation.

In pumping silicious material that is heavy, especially fine sand, if a pump stops while the discharge pipes are filled with spoil, it settles on the bottom and packs so as to be difficult to dislodge. The main thing is to "keep going," and whatever tends to security in this direction is more important than a high efficiency of a pump. An open-vane impeller is preferable, because it affords no chance for the lodgment of stones, or other obstructions drawn in, also because the vanes can be made elastic, which is a very important matter, as it avoids danger of fracture when solids pass through.

The discharge-way should be at the bottom, so that solids will not have to be "thrown over" but may pass out as soon as clear from the vanes, also to avoid charging, which is an annoyance and causes delay. Steel or wrought iron is the most suitable material for dredging impellers. The writer has, in two cases, one for a pump of 200 H.P. and one for a pump of 400 H.P., used successfully five-vaned impellers of cast steel, but these are open to the objection of requiring complete renewal if worn or fractured, and it is proposed in future cases to employ plates of steel riveted to a square extension of the shaft, as shown in fig. 3, but with heavier proportions.

In river dredging, such as is carried on in the Clutha River, in New Zealand, the Murray River in Australia, and in the rivers of California, dredging pumps should be arranged with large catch chambers in the suction pipes, otherwise the pumps have to be arranged to pass without injury stones as large as will go through the pipes. This is possible, but produces a good deal of distortion in the design. In no case is there such ill adaptation of centrifugal pumps as for dredging, which is not to be wondered at perhaps, when practice is so diversified for common purposes.

EFFICIENCY OF CENTRIFUGAL PUMPS.

Under this head is to be noted the singular fact that the commercial efficiency of centrifugal pumps is continually considered in their sale, and stipulated for in contracts, while no such guarantee is expected or even inquired about in the case of piston-pumps of the trade types. The reason of this is, no doubt, mainly accidental, growing out of the new pumps being a kind of mysterious machine that can be driven within 20 per cent. of the working speed and produce no result.

Positive pumps of all kinds, or indeed all but centrifugal pumps, discharge water in proportion to their rate of motion, hence there is a distrust of efficiency in centrifugal pumps, not to be wondered at, when such a pump may be driven at nine-tenths of its normal speed and discharge no water at all. In most of the experiments that have been published, the main element of all, the speed of impellers, has not been varied and the results included. There is, in fact, no way of predetermining the speed of a centrifugal pump, except by the velocity of the discharged water, and changes of this velocity may greatly vary the working efficiency, or, as said, stop the work altogether.

The most careful and extended experiments for efficiency known to the writer have been those at Ferrari, Italy, where six large pumps of 42 in. bore have been tested for efficiency a number of times over a period of years, showing a result of about 65 per cent. of the engine power in water raised. Equal or better results have been attained with some of the recent plants for draining purposes erected here in California, and it is safe to assume that for large pumps and heads, not exceeding 20 ft., an efficiency of 70 per cent. should be realized from this time forward. For greater heads and smaller pumps the efficiency falls off for several reasons. The frictional surfaces of the pipes and waterways increase as their size is diminished, and the friction of impellers as the square of their diameter. One authority, before quoted, claims that the sum of resistances in centrifugal pumps increases as the cube of the velocity. What this may mean is not easy to discern. If velocity of the water is meant, an increase from 6 ft. to 8 ft. per second would call for 2.37 times as much power to raise a given amount of water, or an increase from 5 ft. to 10 ft. per second, which is within the working range of such pumps, would demand an increase of power as 8 to 1.

If, on the contrary, the velocity of the impeller is meant, this is as the square root of the head, and its cube root has no application supposable. For example, for heads of 9 and 36 ft., the square roots will be 3 and 6, or, converted to impeller velocity, 24 and 48 ft. per second respectively. The cubes of these quantities are 13,824 and 110,592, or 8 to 1.

The true factor of resistance is the head, or its resultant the velocity of the impeller, and a safe rule is to assume a possible efficiency of 65 per cent. for pumps of 12 in. and more in bore, and for heads of 20 ft. or less. For small pumps and heads from 20 to 100 ft., deduct 1 per cent. from efficiency for each $2\frac{1}{2}$ ft. of added head. This may not be scientific or mathematical, but it is very nearly true, which is the important point to be learned, and makers of centrifugal pumps will find it to accord with fair experiments. As the question may be asked, and properly too, how such a rule was arrived at, the answer is, by providing steam power to raise water for irrigating purposes in California, and for heads from 40 to 127 ft. There are at least one hundred plants of the kind in the Santa Clara Valley, where observations can be made to determine the consumption of power in proportion to the head of resistance. In this increase of frictional resistance lies the limitation of centrifugal pumping in respect to the head. In piston pumps frictional resistance increases but little with added head and pressure, being only that of flow and of machine bearings. But in centrifugal pumps friction at the sides and periphery of impellers increases in some proportion, as indicated. It is a matter not very well understood, and, so far as known, the only data to be referred to are the experiments of Professor F. G. Hesse, of the University of California, which will be referred to in his contribution before noted.

A head of 127 ft. is above mentioned. This is the highest that has been attempted, and is for raising water from wells at the city water works, San José, California. The limitation in this direction is not known, the present lifts being from water-bearing strata tolerably uniform in depth, and from which the water rises to within the distances named of the required discharge level.—*Industries.*

(TO BE CONTINUED.)

POLE AND ROPE CONSTRUCTION STAGING.

By James F. Hobart, Brooklyn, N. Y.

A form of staging well adapted for heavy construction work, such as brick, terra-cotta and small cut stone material, is illustrated by the accompanying engraving (fig. 1). This staging, or the framework thereof, is constructed entirely of poles and ropes. The former are of spruce, from 12 ft. to 50 ft. long, and are inside of 6 in. in diameter at the large end, and not less than $2\frac{1}{2}$ in. in diameter at the top. Spruce poles are preferable in sections of the country to which they are indigenous. Spruce poles are light, stiff and strong. They are also comparatively cheap.

Well-dried pine saplings may be used for staging purposes, but they are not as strong as spruce, therefore the staging constructed of pine will not carry as great a load as when built of spruce. Yellow pine poles make an excellent stage, but the timber is much heavier than spruce, consequently the labor of building is greater. Ordinary white birch (gray birch) has been employed to advantage in localities where that wood

abounds. The resulting stage is very strong, but the wood is fully as heavy as yellow pine. In tropical countries, where bamboo abounds, a more desirable timber for "rope and pole" stagings could not be conceived.

The rope usually employed is "three-eighths" or "half-inch" hemp. Cotton rope is good; but Manilla rope seems to be avoided by the stage builder—this kind of rope, being harder, does not adapt itself to the work as readily as the softer varieties, which cling like a glove to the smoothest pole. If the staging is to stand for a long time, say several months before removal, tarred rope may be used to advantage. This kind of Manilla rope will "cling;" but if a rope is to be used in its natural state, choose one of the "soft" varieties mentioned above.

The staging illustrated by fig. 1 has not a nail in it, and the material, when removed, will be just as good for another stage as it was when new. There are no nails to pull out, break off or to split the material, as is the case when the ledgers are made of boards or plank and nailed or spiked to the parts. As shown in the illustration, the staging consists of four parts beside the ropes—viz., the posts, girders, ledgers and flooring.

There are two good methods of erecting this form of staging, but one of which is shown in fig. 1; the other method consists of putting the first row of girt poles 8 ft. from the ground instead of 4 ft., as in the example illustrated. Either way is good, according to circumstances and material. In the example illustrated the poles are set into the ground about 6 in., merely to sustain them in a vertical position until the second row of ledgers has been put in place.

The method illustrated is preferable with short poles, but when long ones are to be used the wall may be built up about 8 ft. by the use of a double tier of horses and planking, then the first ledger poles knotted on at the right height to receive ledger poles for the third staging. That would bring the first row of girt poles up to where the second row of ledgers in fig. 1 are lashed directly to the post poles without the use of a girt. This method, shown by fig. 1, answers well for comparatively light work and for walls not very high. For high or heavy work girts should be lashed on at every staging.

Another girt has been started, as shown at the upper left-hand corner of fig. 1. This girt will come about right to receive a set of ledgers after the wall has been built up by a double tier of the horses shown at the left. It is supposed that the stage to be built on the top girt terminates the height of this stage. It will not stand building to a greater height, because there will be nothing to stay the poles between the upper and lower girts after the planking has been removed from the second tier of ledgers. In order, then, to make this stage available for heavy work, every tier of ledgers must be supplied with a row of girt poles. Indeed, for the very heaviest work girt poles are lashed on for every second stage, using only one row of horses between.

Bracing may be applied when necessary, and the bracing may be lashed on and consist of poles of a smaller size if they are to be had. In general practice, however, the same size of pole is used alike for post, girt and brace. Near the center of the illustration a tower is shown, which was constructed to accommodate the "steam Irishman," or power hod-carrying device. The construction of the tower is very plainly shown in the engraving, and no description is necessary except to state that sometimes the pole girts of the tower are omitted and board girts nailed on instead. But there is no need of this, and the "all pole" tower can be made to fill the bill completely.

Usually but one brick is left out of the wall for each ledger, the small end of the short piece of pole being let into the wall, the larger end being lashed to the post. A thin wedge driven in on top of each ledger pole does away with any possibility of the pole's coming out of the wall. It also stiffens the entire staging to a great extent. This staging may be extended to any required height within limits of the strength of the material used, and as soon as the staging gets high enough to enable the workman to reach the top of a pole, it should be spliced by holding up another pole and lashing it securely to the lower

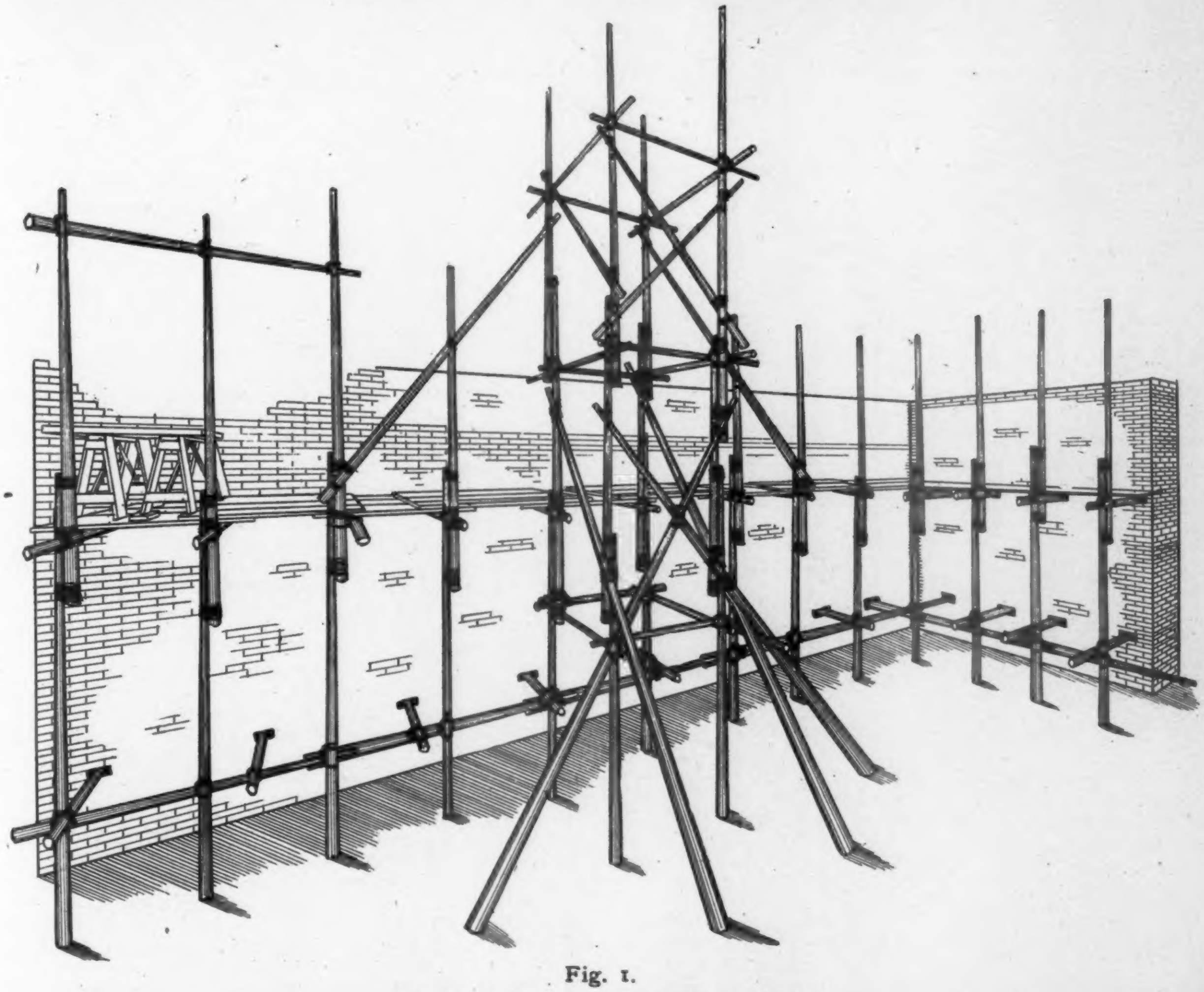


Fig. 1.

POLE AND ROPE CONSTRUCTION STAGING.

pole. Three men are needed to do this—two to hold the pole in position and one to apply the rope.

A fastening like that shown by fig. 2 is the proper way to apply the rope. It will be seen that the fastening is commenced at the bottom, and ends at the top, where the end of the rope is fastened by tucking it down between the winding and the poles, then pulling the rope end tightly under the winding as shown. The beauty of this style of rope hitch is that heat, cold, rain or sunshine has no effect upon the holding power of the fastening. When the rope gets wet it simply shrinks a little, making the fastening all the tighter. When sunshine dries and stretches the ropes, the poles sag a very little, and this tightens the coils again at once. The effect of many weeks' exposure to alternation of temperature, moisture and dryness, is perhaps only to lower the upper stagings an inch or two at the most.

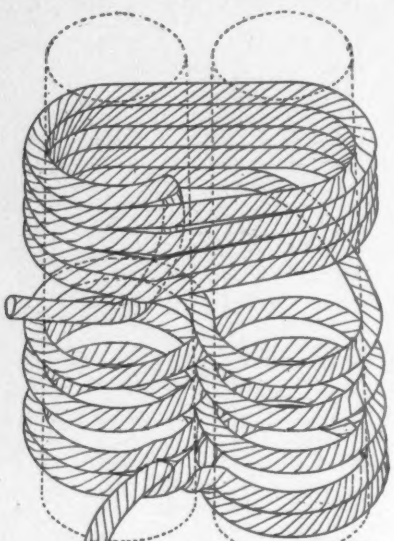


FIG. 2.
KNOT FOR SPLICING POSTS

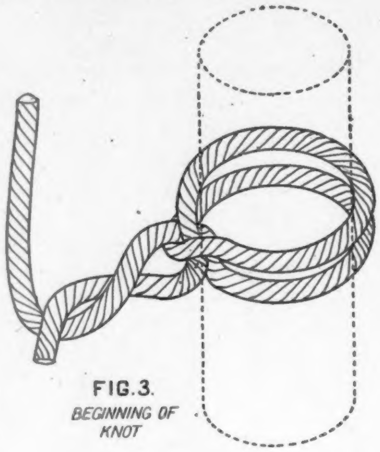


FIG. 3.
BEGINNING OF KNOT

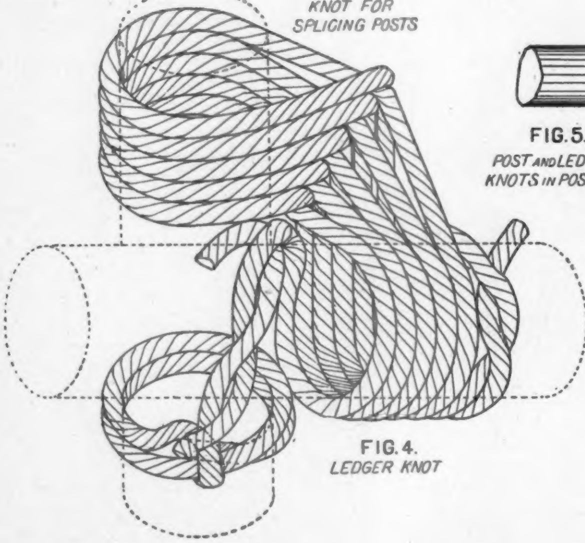


FIG. 4.
LEDGER KNOT

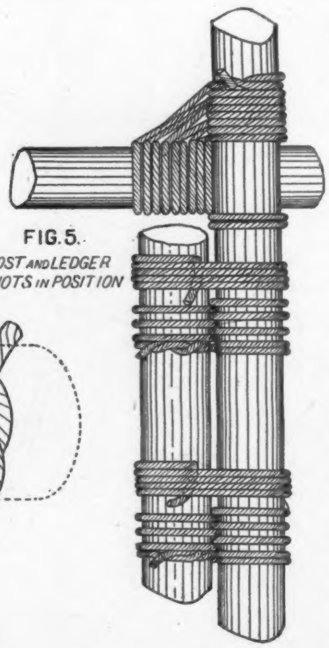


FIG. 5.
POST AND LEDGER KNOTS IN POSITION

It will be quite a task for the novice to put up a fastening like that illustrated by fig. 2. The first step is to make the hitch shown by fig. 3—something like the ordinary "timber hitch"—two complete turns of the rope being made around the top of the pole, and the ends of the rope being disposed of as shown in the engraving. The second pole, or "top-mast," is next placed in position and a turn of the rope taken around it, after which the rope is wound alternately around each pole until it carries from three to six turns (according to strength of stage desired), then the coils are passed around both poles, as shown in fig. 2, from four to eight turns being made and the rope's end fastened as above described.

For putting on a ledger pole, the hitch shown by fig. 4 is used. This is started in precisely the same manner that the vertical splice was commenced—the double-turn hitch being put on and the ledger pole *laid on top* of it. Next, one turn is taken around the ledger pole and the rope pulled very taut; the horizontal pole can roll in the rope, and a pull on the rope, accompanied by a twist on the pole by the assistant who is holding it in position, makes the rope strain up very tight. A turn of the rope around the post must next be taken, then a turn around the ledger, another around the post, and so on, alternating from one to the other until from five to ten turns have been put on, according to the requirements of strength, etc.

The girts should be attached to the posts in this manner and the ledgers made fast to the girts in a similar manner. When no girt is used, the ledger poles should be attached directly to the posts by the same kind of a knot. Indeed, it is only necessary to use the two hitches illustrated. The workmen are often tempted to make a simple hitch in fastening ledgers to girts, but don't do it. It is easy to wind the rope right around both poles without taking the "alternate" hitches shown by fig. 4; but a stage *cannot* be too well or strongly built, and the man who "scamps" work of this kind should be run out of the business.

Fig. 5 illustrates a completed vertical or post splice, and also shows the back or opposite side of the ledger or girt hitch (fig. 4 showing the front side of the knot, fig. 4 the back side). In putting on the rope lashings care must be taken that there is no loose bark to slip after the rope is in place. Knots or other rough parts should be trimmed smooth. If a girt or a ledger comes where there is a vertical or a horizontal splice, pay no attention to either, but put the rope lashing right over the hitch already made, just as if it was the middle of a single stick instead of a joint between two poles. Do the work thoroughly and no accident will ever happen on your job through failure of the construction staging.

THE AUXILIARY MACHINERY OF A MODERN CRUISER.*

By Frederick Arsenius.

While there is some difference in the amount and arrangement of auxiliary machinery in cruisers of the same class, the description of one will suffice for the whole class, and I have chosen for this sketch a cruiser which, through her wonderful speed performance a short time ago, is well known to everybody—the protected cruiser *Columbia*—the greatest triumph for our Navy Department and for her builders, William Cramp & Sons' Ship and Engine Building Company. It is astonishing what a number of different steam engines it takes to run one of these great ships, although they have a crew of a number that would seem sufficient to handle almost anything, yet there is such a variety of work to be performed constantly that modern practice is to depend on the crew mainly for the fighting part of the business, and to feed and regulate that mass of machinery which makes the ship inhabitable and gives it motion. To lift the heavy anchors, to hoist shot and shell, and to lift the ashes from the depths of the stokehold would be too slow a process if done by hand, and speed is now the motto. The systems of draining and pumping to keep the ships free from water, to feed the boilers and supply water for various purposes to different parts of the ships, and the electric lighting and ventilation must to a great extent be duplicated, so that no ordinary breakdown will disable the interior workings of the ships. Let us make a trip through the ship. Commencing down in the engine rooms we find, first, some parasites to the three colossal main engines (42, 59 and 92 in. × 42 in. stroke). One, the turning engine, consists of two vertical single-cylinder engines 8 in. diameter and 6 in. stroke. They have a common shaft with a worm in the middle, while

* Paper read at the Swedish Engineers' Club of Philadelphia.

through gearing turns the main shaft to a suitable position for starting. Another one is the reversing engine, a single upright cylinder 16 in. × 22 in. This has on top a hydraulic controlling cylinder, which can be used in case of breakdown, but which in ordinary running serves as an excellent guide for the piston-rod which acts through a lever on the high-pressure valve liners. Independent of the main engine stands in each of the three engine-rooms one air pump connected to the respective condensers. They are known as Blake's vertical "twin" air pumps, each having two steam cylinders 16 in. diameter, two air cylinders 31½ in. diameter, 21 in. stroke. They work slowly and steadily, about 16 double strokes per minute, and are remarkably economical, as they require only about ¼ of 1 per cent. of the total H.P.; they are very reliable, and need very little attention. Then in each engine-room are two circulating pumps for forcing cold water through the condenser, and also for discharging bilge water directly overboard. They are centrifugal pumps, each driven by a vertical single-cylinder engine, but they go in pairs and rest on the same bedplate. The pair can drive 14,000 galls. or 54 tons of water per minute through the condenser tubes, or pumps out the bilge at that rate in case of a leak. These pumps, as well as the turning and reversing engines, are furnished by the builders.

At the outside bulkhead in each engine-room is a double horizontal Blake pump. A fire, feed and bilge pump, with 12-in. steam cylinder, 8½-in. water cylinder, and 12 in. stroke. These pumps connect with the feed water tanks for feeding the boilers, with sea valves for pumping water into the fire main, also through valve boxes with the different drains for discharging bilge water overboard. Each engine-room has hanging on the dividing transverse bulkhead a Blake duplex vertical fire and bilge pump. Those in the forward engine-rooms are 12 in. × 7½ in. × 12 in., and in the after one 14 in. × 9 in. × 12 in. Their purpose is also to supply the fire main from the sea and to discharge outboard from valve-box connections with main and secondary drains, bilge, and water-bottom suctions. There are also on the same bulkhead three sets of pumps of the same make as the former, but much smaller, having 7½-in. steam, 4½-in. water cylinder and 10 in. stroke. They are called water service pumps, for their duty is to furnish a cold shower to the main journals, thrust bearings and other parts likely to be heated by running. They also supply the fire service. In the after engine-room is a Sturtevant blower or ventilating fan, 36 in. diameter and 17 in. wide, driven by a 3½ in. × 2½ in. double-enclosed engine of about 4 I.H.P. It will exhaust 8,000 cub. ft. of air per minute at 600 revolutions. Overhead in the two forward engine-rooms, right under the armor grating and nearly covered from sight by twisted masses of pipe, hang two Wheeler auxiliary condensers, really condensers for auxiliary machinery. They are 9 ft. long and 30 in. diameter, directly mounted upon combined air and circulating pumps, each having 12-in. steam cylinders, 10-in. air cylinders, 10-in. water cylinder and 12 in. stroke, which, running at 100 ft. piston travel, have a capacity of 400 galls. per minute each. In one boiler-room we find at its forward end on each side a large vertical Blake duplex pump, with two steam cylinders 12 in. diameter, two water cylinders 7½ in. and 12 in. stroke. On the starboard side is the main feed pump, which takes water from the tank feed pipe connecting with the feed tanks, and pumps it into the boilers at the rate of 500 galls. per minute. The one on the port side is the auxiliary feed pump, for while it has the same duty as the main feed pump, it has also valve-box connections with sea for supplying fire mains and flushing boilers, with main and secondary drains and bilge suctions, and for emptying boilers. They can discharge either upward through feed pipes to outboard delivery or down through a bottom valve. They are placed in each boiler-room, and there are eight in all. In each boiler-room are four large blowers, 16 in all, used to force air into the fire-room according to the closed stokehold forced-draft principle. They are 5 ft. diameter and 14 in. wide at outlet, driven by 5 in. × 4 in. double-enclosed engines, and are capable of delivering 25,000 cub. ft. of air per minute, with 4-oz. pressure and 650 revolutions, requiring about 37 I.H.P. each. They are, however, only expected to supply 240,000 cub. ft. per minute altogether, under a pressure of 1 in. of water. These, as well as all other blowers in the ships, are of the well-known Sturtevant make.

On the platform deck forward we find there first two small double-hoisting engines, 4½ in. × 4½ in., located in the passing room in the midst of magazines, and used to hoist powder and shell to the gun deck. Aft of the magazines, and forward of the boiler space, is the dynamo-room or electric light plant. The ship has an installation of about 512 lights, 16 and 50 candle-power, and search lights. The generating plant consists of two 32-kilowatt marine generators with attached dynamos, of the General Electric Company's make, having a speed of 400 revolutions, and supplying 400 ampères at a pressure of 80 volts. There are also two small electric fans 21 in. × 5 in. Aft of the engine-room on platform deck are two ammunition hoists, similar in design and size to the forward ones. After this we come across the immense steering engine—a double-cylinder horizontal engine 13 in. diameter × 10 in stroke. It is geared to a very large screw which works two nuts connected by rods to the secondary tiller, which again turns the main tiller on the compound lever principle. This steering engine can be worked from below protective decks, from bridge deck, pilot house, conning-tower, and flying bridges.

On the protective deck we come across a variety of blowers. Two of them, 4 ft. diameter, stand at the head of the forward engine hatch, draw the hot and foul air out of the engine-rooms, and blow it up through the ventilators; capacity, 9,000 cub. ft. The two donkey boiler-rooms and the distilling-room have each one blower about 3 ft. diameter, and they are needed to keep the air fresh. About midships on each side are embedded among the coal bunkers the ship's blower rooms, each containing two blowers 4 ft. diameter and 15 in. wide at the outlet, with 4 in. × 3 in. double-enclosed engines, capable of 600 revolutions and 10,000 cub. ft. per minute at a pressure of 2 oz. They are the heart and pulse of the ship's ventilation. They draw through the main ducts and pipes with their hundred of arms reaching into every coal bunker, every magazine, and every state-room above and below. They draw the vitiated air out, or, if necessary, can blow in fresh air. The two donkey boiler-rooms have each two pumps, small duplex vertical, 6 in. × 4½ in. × 7 in., one a main feed pump, the other an auxiliary feed pump.

The distilling-room is quite an interesting little museum of various steam pumps. One large horizontal single-cylinder is a circulating pump for the distiller, taking water from sea valve at bottom, and after forcing it through the distiller, discharges into the head. This is a Davidson pump 8 in. × 9 in. × 12 in., capable of 260 galls. at 100 revolutions. Another pump has two water cylinders 2½ in. diameter, one steam cylinder 3½ in. diameter and a common stroke of 4 in. One end of this takes sea water from discharge of large pumps and feeds into the Baird evaporator. The other end takes the distilled water from the filters and delivers to the ship's tanks, and another small pump, single horizontal, 3½ in. × 2¼ in. × 4 in., takes the drain from the traps and delivers it to the feed tanks. There stands also the large wrecking pumps, whose sole duty is to pump from connection with the main drain, directly overboard, water collecting in the lower compartments, which the other pumps are unable to handle. It is a Blake horizontal single-cylinder, 10 in. steam, 14 in. water and 18 in. stroke, and can at ordinary speed, through its 8-in. delivery pipe, force 840 galls. per minute. To finish this deck, there is an upright engine for driving the machine tools in the engineer's workshop.

Going up to the gun deck forward our attention is first called to a mass of 20 tons of machinery which we find to be a windlass, of the American Ship Windlass Company's make, generally known as the Providence windlass. It is driven by two vertical engines with 12-in. cylinder diameter and 14 in. stroke, built for 2⅛-in. chain and 10,000-lbs. anchors. It also drives a capstan located on the upper deck. On this deck are also located the ash hoists, which hang a few feet above the deck of the boiler-room and dividing bulkheads. They are double-cylinder engines 4½ in. × 4½ in., with a drum and reversing gear. They are very neat and clever, and can be worked from the upper or gun deck from either side as required. Williamson Brothers are the makers of these as well as all other hoists and the steering engine. There are eight of these ash hoists. On the upper deck is only one engine, and that is the Allen dense air ice machine. This consists of an air compressor 5¾ in. diameter × 10 in. stroke, which compresses air 60–210 lbs., and passes it into a cooler, which takes off the heat of compression, and thence into the expander, a regular cut-off machine, where the air is admitted during part of the stroke, then cut off, and the air is expanded as the stroke is finished. During this expansion the air is cooled to a very low temperature—practically 60° F. below zero. The return stroke pushes this cold air through the pipes that encircle the refrigerating-room and coils through the scuttle butt, and is then returned to the machine to go through the same process over and over again. The steam cylinder for driving is 7 in. diameter × 10 in. stroke, and uses 50 lbs. of steam. Above the deck is the bridge deck, and there stand two deck hoists 8 in. × 8 in. double-cylinder reversible engines. This finishes the steam machinery with the exception of engines for small boats standing on this deck. They are fitted with very complete but diminutive marine engines of the compound type, but these have of course their own steam generators. The 30-ft. cutter

has an engine 3½ in. × 7 in. × 6 in. stroke; and the 33-ft. steam barge one 4 in. × 7 in. × 7 in. stroke.

In addition to steam machinery, one capstan is worked by hand, as are five 7-in. Calkin's deck pumps that draw from principal compartments in the hold, the valve boxes, the sea, and deliver it to the fire main or discharge overboard. There is also one 5½ in. force pump to supply water to baths, cisterns, etc., and one 3-in. pump for fresh-water service; a number of small hand pumps, hand steering gear, and machinery for working the heavy guns.

Summing up, we find 39 steam pumps with 60 steam cylinders, 26 blowers or ventilating fans with 52 steam cylinders, 3 starting engines and 5 reversing engines, with 9 steam cylinders, 8 ash hoists with 16 steam cylinders, 4 ammunition hoists, 2 deck hoists, 1 steering engine, 1 windlass, 1 shop, 1 air and 2 electric light engines with 23 steam cylinders, making a total of 88 engines with 160 steam cylinders outside and separate from the 3 main engines with their 9 cylinders.

It takes, of course, a great deal of steam to run these auxiliary engines. From trial trips of the United States steamships *Philadelphia* and *San Francisco* I find that the auxiliary machinery took a little over 3 per cent. of the total I.H.P., and that the proportion would give for this ship about 650 I.H.P. But they are not all run at the same time; those running during the *Columbia's* trial trip took only about 600 I.H.P. This does not include the ship's or engine-room blowers, no hoists of any kind, no distilling-room pumps, nor many others, so that if they are all working at the same time they would require 1,200 I.H.P., which is as much as it takes to drive a steamer 254 ft. × 35 ft., and 2,800 tons, at a speed of 12.3 knots an hour. There are pumps enough to discharge 515,000 galls., or 193 tons of water per minute, and blowers enough to blow in or out 481,000 cub. ft. of air per minute.

Ticket-Selling on the North London Railway.—The *Engineer* says that the penny-in-the-slot system of selling tickets has been adopted by the North London Railway. The arrangement is for workmen's tickets only.

THE BEAUMONT-WALLINGTON HIGH-SPEED ENGINE.

ONE of the most interesting adaptations of the type of valve gear that is operated from the connecting-rod that we have ever seen was illustrated in a recent issue of the *Engineer* (London), to whom we are indebted for the engravings and description of the engine. The engine illustrated is of the single-acting description, with central valve contained in a hollow extension of the piston-rod, which is actuated by a new radial gear. The latter is also a new departure in this

FIG. 1

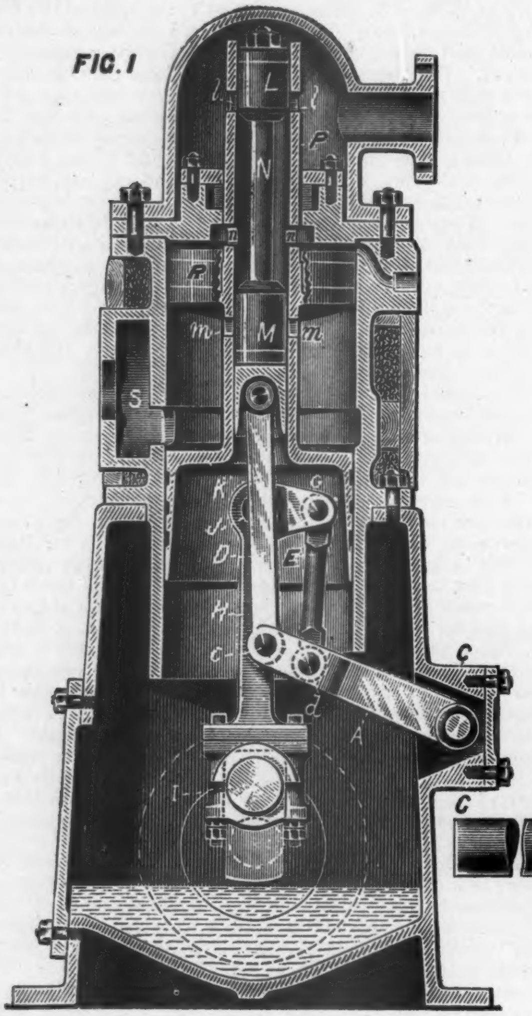
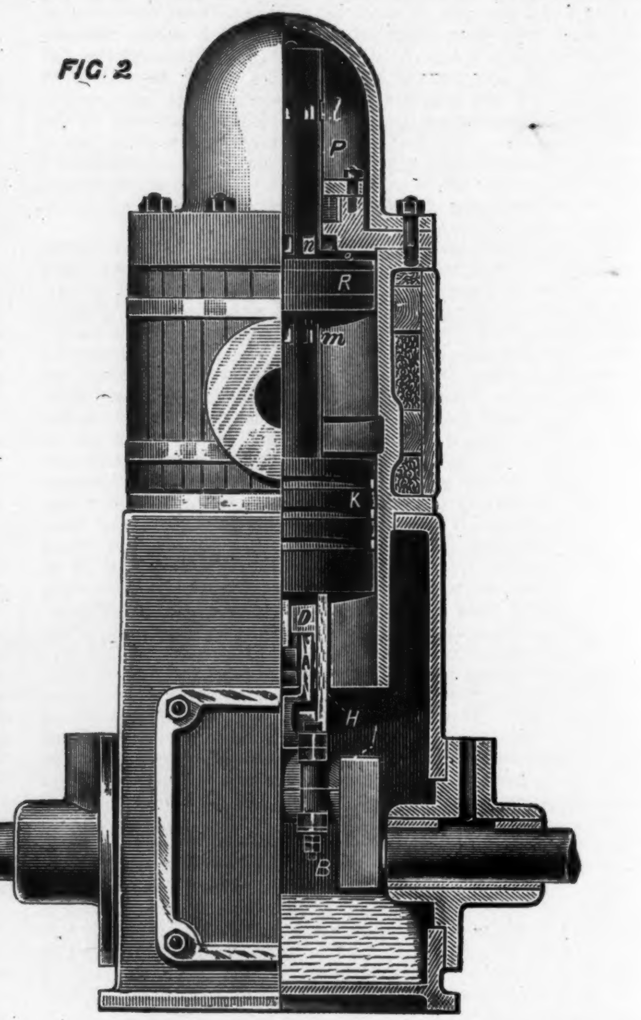


FIG. 2



class of engine. This gear gives to the valve a motion which causes a very perfect distribution of steam in the cylinder. During one revolution of the crank there are four distinct movements of the valve: (1) A quick upward movement opening the valve for admission; (2) a quick downward motion performing cut-off; (3) a longer period of comparative slow movement during expansion; (4) another quick movement opening the exhaust port, which remains open till nearly the top of the return stroke, when it closes, forming the steam cushion. On referring to the illustration, it will be seen that the connecting-link *D* is attached to the extremity *c* of a vibrating lever, *A*; an intermediate point *d* in this lever is connected by a link, *E*, to a short arm, *G*, at right angles to, and forged solid with, the connecting-rod *H* at the cross-head end.

All the functions of lead, cut-off, expansion, exhaust and compression are performed thereby in a simple, quick and accurate manner. In order to show how this is attained, we may suppose the connecting-rod *H* to be disconnected from the crank-pin, and moved from its top position, as shown in the illustration, to the center of the stroke in a straight line, without swinging the lower end to either side; it is evident that the arm *G* would move down the same distance as the piston, consequently the intermediate point *d* on the lever *A* would also travel the same distance, but the extreme point *c* would move a greater distance; the difference of the distance

of the travel of these two points c and d respectively being equal to the lap and lead of the valve. Now, if the connecting-rod be swung to the right until it comes to its proper position in the crank circle, it is evident that the end of the lever G would move upward, carrying with it the link E, lever A and the valve-link D, together with the valve. The actual movement of the valve relatively with that of the piston in half a revolution is therefore equal to the difference between the travels of the points d and c, together with the motion imparted by means of the arm G. The amount of the steam-port opening is determined by the length of this arm together with the distance between d and c, and by varying these any degree of expansion can be obtained. It will be seen that the link D is always in compression with the link E in tension, so that any slight wear in the one is compensated by wear in the other. The gear is, therefore, self-adjusting.

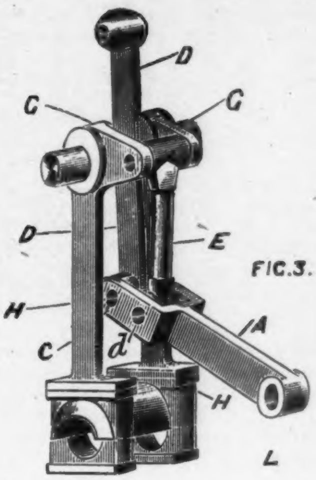


FIG. 3.

These engines are made either simple, compound or triple-expansion, with either one or two cranks. The cranks are of steel and the bearings of phosphor-bronze. The crank-chamber is closed, as shown in the engravings, and forms a receptacle for the lubricant, in which the crank revolves, as is usual in this class of engines. The engines are made under the patents of Messrs. Beaumont and Wallington by the Blair Engineering Company, Bellenden-road, Peckham, S. E.

COAL CONSUMPTION; EMPIRE STATE EXPRESS.

STATEMENT RELATIVE TO MILEAGE, SPEED AND FUEL CONSUMPTION OF THE NEW YORK CENTRAL & HUDSON RIVER RAILROAD CLASS N ENGINE, DRAWING THE EMPIRE STATE EXPRESS TRAIN IN JULY, 1894.

Weight of engine and tender in working order	91 tons. 0 cwt.*
Average weight of train, passenger, baggage and mail (exclusive of engine and tender)	186 " 10 "
Average weight of train, passenger, baggage and mail (including engine and tender)	277 " 10 "
Time schedule (deducting stops)	77 hrs. 31 min.
Deduct time made up	79 "
Actual running time	76 " 12 "
Total train miles	3,848
" light " (without cars)	26
" mileage	3,874
Average speed per hour	50 $\frac{50}{100}$ miles.
Total weight of coal consumed (exclusive of kindling)	53 tons. 6 cwt.*
Actual consumption per train mile	31 $\frac{04}{100}$ lbs.
Consumption per train mile (including kindling)	32 $\frac{38}{100}$ "
Total ton miles, including passenger, baggage and mail (exclusive of engine and tender)	717,504
Total ton miles, including passenger, baggage and mail (including engine and tender)	1,067,968
Consumption per mile per ton of train, including passenger, baggage and mail (exclusive of engine and tender)	2 $\frac{662}{1000}$ oz.
Consumption per mile per ton of train, including passenger, baggage and mail (including engine and tender)	1 $\frac{788}{1000}$ oz.

STATEMENT OF LIGHT TRIP (WITHOUT CARS) OF CLASS N ENGINE 999, BETWEEN ALBANY AND SYRACUSE AND RETURN, RUN ON SAME SCHEDULE TIME AS ABOVE.

Weight of engine and tender	91 tons. 0 cwt.
Total mileage	296
" weight of coal consumed	1 ton. 14 cwt.
Actual consumption per mile	12 $\frac{87}{100}$
Total ton miles, engine and tender	26,936
Consumption per mile per ton	2 $\frac{26}{100}$ oz.

ANALYSIS OF COAL USED IN TEST.

Water	.25
Volatile matter	32.01
Fixed carbon	62.96
Sulphur	.48
Ash	4.30
Total	100.00

*Tons of 2,240 lbs.

On July 24 the same engine referred to above ran from Syracuse to Albany, 148 miles, in 144 minutes, and stopped 3 minutes at Utica, making the average rate of speed while running 62.98 miles per hour. Between Utica and Albany it ran 95 miles in 90 minutes, or at the rate of 63.33 miles per hour. The run from Albany to New York, 142.88 miles, was made in 2 hours and 57 minutes. The train consisted of four cars.

ACCIDENTS TO LOCOMOTIVE ENGINEERS AND FIREMEN.

THE object of publishing this monthly list of accidents to locomotive engineers and firemen is to make known the terrible sacrifice of life and limb that is constantly going on among this class of people, with the hope that such publications will in time indicate some of the causes of accidents of this kind, and to help lessen the awful amount of suffering due directly and indirectly to them. If any one will aid us with the information which will help make our list more complete or correct, or who will indicate the causes or the cures for any kind of accidents which occur, they will not only be doing us a great favor, but will be aiding in accomplishing the object of publishing this report, which is to lessen the risk and danger to which the men to whom we intrust our lives are exposed.

The only, or the chief source of information we have, from which our report is made up, is the newspapers. From these the following list of accidents, which occurred in July, has been made up. Of course we cannot report those of which we have no knowledge, and doubtless there are many such.

ACCIDENTS IN JULY.

Fort Scott, Kan., July 1.—A freight train on the Pittsburgh & Gulf Railroad ran into a stock train on the Fort Scott & Memphis Railroad at Last Chance Crossing this morning. The engine of the freight went over, and the fireman, Jack Dobbins, fell under the engine and was crushed to death.

Greenville, Me., July 1.—An express train on the Canadian Pacific Railroad was wrecked on a bridge near this place today. Engineer Fred Leavitt was killed, and Angus McDonald, fireman, fatally injured.

Pine Bluff, Ark., July 2.—A freight train on the St. Louis Southwestern Railway went through a trestle 2 miles south of New Louisville. Engineer Ferguson was killed outright and Fireman O'Neil fatally scalded. The trestle had been fired and burned nearly through.

Chicago, July 3.—A passenger train on the Baltimore & Ohio Railway was ditched at Rock Island Junction to-day by strikers. The engineer was badly hurt in jumping.

Pueblo, Col., July 2.—Engineer Loftus and his fireman, who were running on the Denver & Rio Grande Railroad, were hung by a mob south of here to day.

West Superior, Wis., July 6.—Strikers ditched a train on the Chicago, St. Paul, Minneapolis & Omaha Railroad to-night, derailing the engine and seriously injuring the engineer.

Ottumwa, Ia., July 7.—A passenger train on the Chicago, Fort Madison & Des Moines Railroad struck an obstruction this evening. The engine was ditched, killing the engineer and fireman.

New York, July 8.—The limited express on the New York Central & Hudson River Railroad struck a car door which had fallen from a south-bound train across the north-bound tracks, and the engine was derailed. The engine ran for some distance and finally struck an iron water tank; the engineer and fireman jumped before the engine struck the tank and escaped with slight injuries.

St. Louis, Mo., July 9.—An express on the Big Four Railroad ran into a freight train at Wann, Ill., to-night. Oliver Davis, the fireman, was fatally injured and the engineer seriously hurt. The freight train had not pulled on to the switch far enough to clear the main line.

Bethlehem, Pa., July 10.—The Buffalo Express on the Philadelphia & Reading Railroad was wrecked this evening by a misplaced switch. The engineer, Matthew Bickel, was fatally injured. Fireman James Hutchinson was seriously scalded, but in spite of this he pulled Bickel from the wreck and then drew the fire from the fire-box.

Sacramento, Cal., July 11.—A passenger train on the Southern Pacific Railway was derailed by strikers 3 miles from here to-day. Some timbers were loosened from the trestle, which caused the engine and two mail cars to go over. Engineer Samuel B. L. Clarke was killed.

Neosho, Mo., July 12.—A freight train on the Kansas City, Pittsburgh & Gulf Railroad was derailed 5 miles south of here to-day by an open switch. The engine was turned over and caught Engineer Traver under it, killing him instantly. Fireman Grant Grattis was badly scalded and cut.

LOCOMOTIVE RETURNS FOR THE MONTH OF MAY, 1894.

Name of Road.	Number of Serviceable Locomotives on Road.	Number of Locomotives Actually in Service.	Locomotive Mileage.					Av. Train.		Coal Burned per Mile.						Cost per Locomotive Mile.							Cost per Car Mile.		Cost of Coal per Ton.
			Passenger Trains.	Freight Trains.	Service and Switching.	Total.	Average per Engine.	Passenger Cars. *	Freight Cars.	Passenger Train Mile.	Freight Train Mile.	Service and Switching Mile.	Train Mile, all Service.	Passenger Car Mile.	Freight Car Mile.	Repairs.	Fuel.	Oil, Tallow and Waste.	Other Accounts.	Engineers and Firemen.	Wiping, etc.	Total.	Passenger.	Freight.	
										Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	$
Atchison, Topeka & Santa Fé	855	...	...	...	1,891,560	2,182,425	2,831	...	...	...	...	...	79.24	...	...	3.97	7.79	0.20	1.31	6.67	0.15	20.09	...	...	1.78
Canadian Pacific	603	...	491,010	509,775	414,468	1,415,253	...	...	...	...	...	...	64.25	...	...	2.19	9.99	0.33	...	5.64	1.28	19.43	...	...	3.13
Chic., Burlington & Quincy	541	...	...	...	...	1,416,246	...	4.90	19.12	...	...	...	85.03	...	...	4.06	7.64	0.16	0.18	6.84	0.04	18.92	...	...	1.81
Chic., Milwaukee & St. Paul	...	855	...	...	...	2,162,965	...	...	...	...	...	...	65.11	...	...	4.10	8.02	0.26	...	6.93	...	19.31	...	...	2.40, 2.80
Chic., Rock Island & Pacific	...	...	501,623	929,988	334,178	1,765,789	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Chicago & Northwestern	1010	...	823,282	1,339,274	598,024	2,760,580	2,733	...	...	...	...	...	80.54	...	...	3.29	7.46	0.28	...	6.27	0.85	18.15	...	...	1.83
Cincinnati Southern	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Cumberland & Penn.*	23	23	7,818	20,815	...	28,633	1,245	...	...	...	...	...	82.46	...	...	8.13	4.11	0.35	...	...	1.78	14.37	...	...	...
Delaware, Lackawanna & W. Main L.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Morris & Essex Division	163	...	187,994	149,590	102,045	439,629	2,697	...	...	...	...	...	66.22	...	...	4.31	10.29	0.38	...	6.28	...	21.26	...	...	3.08
Flint & Père Marquette	...	...	89,703	65,005	61,783	216,491	2,488	...	...	50.00	66.66	...	...	...	...	3.356	5 275	0.13	...	5.20	0.852	14.81	...	...	1.71
Hannibal & St. Joseph	66	66	65,223	165,341	31,489	262,053	4,095	4.96	16.38	...	...	...	74.62	13.49	5.54	3.28	5.92	0.10	0.14	6.59	0.02	16.05	...	...	1.77
Kansas City, Ft. S. & Memphis	142	...	95,929	225,087	83,060	404,076	3,259	...	...	...	...	...	63.69	...	...	2 96	4.28	0.21	0.36	7.30	...	15.11	...	...	1.30
Kan. City, Mem. & Birm	41	37	34,929	39,697	9,329	83,955	2,268	...	...	...	...	...	61.01	...	...	4.42	3.24	0.24	0.31	7.00	...	15.21	...	...	1.04
Kan. City, St. Jo. & Council Bluffs	36	36	52,269	41,521	43,352	137,142	3,809	5.03	24.82	...	...	...	67.11	13.13	4.28	2.75	6.11	0.12	0.15	6.45	0.04	15.62	...	...	1.85
Lake Shore & Mich. Southern	593	...	423,783	660,441	367,869	1,452,093	2,448	...	...	56.72	86.21	38.97	64.59	...	...	3.30	4.57	0.05	0.12	6.75	0.16	14.95	...	...	1.41
Louisville & Nashville	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Manhattan Elevated	...	298	779,647	...	68,857	848,504	2,847	...	...	...	...	...	37.68	...	...	2.60	7 60	0.20	...	9.00	...	19.40	...	...	4.02
Mexican Central	148	130	...	...	...	450,350	...	...	...	...	...	...	66.66	...	...	4.71	13.64	0.40	...	4.68	...	...	...	...	4.27
Minn., St. Paul & Sault Ste. Marie	104	77	79,188	88,932	38,871	206,991	...	...	...	...	...	...	56.96	...	4.20	2.79	8.31	0.23	...	6.47	...	17.80	...	...	2.87
Missouri Pacific	351	...	...	...	...	991,503	3,403	4.27	17.91	...	...	...	79.43	...	...	4.71	5.79	0.29	1.21	6.32	1.37	19.70	3.92	1.33	1.43
Mobile & Ohio	107	86	76,251	159,388	53,313	288,952	3,360	...	20.30	...	...	...	62.83	...	...	3.05	4.50	0.22	0.61	5.41	0.97	14.76	...	...	1.43
N. O. and Northeastern	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
N. Y., Lake Erie & Western	...	631	438,289	694,498	235,541	1,368,328	...	...	...	88.30	142.07	178.90	...	20.60	5.60	4.36	7.69	0.35	1.99	7.39	1.29	22.07	...	...	1.36
N. Y., N. H. & H., Old Colony Div	...	...	375,993	163,172	180,160	719,325	...	4.00	17.90	...	...	...	62.11	16.30	5.90	3.47	9.32	0.57	...	7.18	0.76	21.30	...	...	...
N. Y., Pennsylvania & Ohio	...	276	131,827	122,351	314,978	569,156	...	...	...	59.80	114.4	132.30	...	11.40	5.50	4.08	5.05	0.29	2.57	6.99	1.24	20.17	...	...	1.11
Norfolk & Western, Gen. East. Div.†	...	...	98,750	312,098	49,678	460,526	2,774	5.12	21.18	46.28	120.48	...	83.38	9.00	5.70	6.51	3.53	0.29	...	...	...	10.33	...	...	3.30
General Western Division†	...	...	104,173	393,274	61,715	559,162	2,900	5.48	17.48	76.00	126.00	...	118.00	13.87	7.69	11.65	3.98	0.27	...	...	...	15.90	...	...	...
Ohio and Mississippi	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Philadelphia & Reading	...	...	436,399	272,731	762,487	1,471,617	...	...	...	...	...	...	81.07	...	...	4.78	4.75	0.23	...	5.80	0.47	16.03	...	...	...
Southern Pacific, Pacific System	723	650	664,758	750,929	270,587	1,686,274	2,994	5.06	13.92	...	...	...	66.64	...	...	6.10	16.46	0.20	2.00	7.25	1.22	33.23	...	...	4.81 4/10
Union Pacific	...	...	509,023	905,794	333,351	1,748,168	3,967	6.15	18.89	...	...	...	97.04	...	...	9.62	9.80	0.40	...	8.01	1.22	29.05	4.23	2.03	2.01
Wabash	418	325	425,982	512,296	190,542	1,128,820	3,473	4.62	16.78	50.93	95.24	55.60	75.36	12.77	5.67	3.35	4.32	0.24	...	5.55	0.92	14.38	2.73	0.97	1.17
Wisconsin Central	149	108	136,382	155,491	80,362	372,235	3,444	...	...	...	...	...	71.97	...	...	2.58	8.31	0.16	...	6.34	0.75	18.14	...	...	2.29

NOTE.—In giving average mileage, coal burned per mile and cost per mile for freight cars, all calculations are made on the basis of *loaded* cars. Empty cars which are reckoned as one loaded car are not given upon all of the official reports, from which the above table is compiled. The Union and Southern Pacific, and New York, New Haven & Hartford rate two empties as one loaded; the Kansas City, St. Joseph & Council Bluffs and Hannibal & St. Joseph Railroads rate three empties as two loaded; and the Missouri Pacific and the Wabash Railroads rate five empties as three loaded, so the average may be taken as practically two empties to one loaded

* Switching engines allowed 6 miles per hour; wood, construction and gravel trains, 10 miles per hour.

† Wages of engineers and firemen not included in cost.

Terre Haute, Ind., July 12.—A passenger train on the Big Four Road was wrecked 10 miles east of here to-day. The engine was derailed and went into a ditch. Engineer Norman was killed. The disaster was caused by train wreckers.

Peoria, Ill., July 12.—A double-header freight train on the Toledo, Peoria & Western Road was ditched by running into a cow between Canton and Bushnell to-night. William Schwartz, one of the engineers, was killed, and John Quinlan, the other engineer, and William Schellbager and Ed. Beam, firemen, were injured.

Columbus, O., July 13.—An engine on a freight train on the Baltimore & Ohio Railroad jumped the track at Pan Handle Crossing this evening and rolled down a 10-ft. embankment; the engineer was caught underneath the engine and crushed. Fireman Thomas Carr was slightly injured.

Terre Haute, Ind., July 13.—The Big Four passenger train was wrecked at Fontainet by strikers this morning. Engineer Moorman and his fireman were killed.

Momence, Ill., July 13.—An express train on the Chicago & Eastern Illinois Railroad was wrecked here to-day by a misplaced switch. William H. Lunt, engineer, was seriously injured, and Fireman Albert Lester had his leg broken and shoulder dislocated.

Salida, Col., July 13.—A train on the Denver & Rio Grande Railroad was wrecked at Marshall Pass to-day. The engineer was fatally injured and the fireman seriously.

Lynn, Mass., July 13.—A passenger train on the Boston, Revere Beach & Lynn Railroad ran into a gravel train this afternoon. The engineer of the gravel train, Charles S. Reach, was thrown from his cab and injured about the head.

Louisville, Ky., July 14.—There was a head-end collision on the Louisville & Nashville Railroad at Colesburg to-night; both engines were badly wrecked. Engineer Frank Dudley was killed and Fireman Fay McCormick was slightly injured.

Easton, Pa., July 16.—A freight train on the Lehigh Valley Railroad ran into a gravel train at Kennedy to-day, and later a west-bound mixed train ran into the wreck. Robert Cline, engineer, and Samuel Filkenson, fireman, were seriously injured. The accident was due to the carelessness of a flag man.

Battle Creek, Mich., July 16.—A passenger train on the Grand Trunk Railroad was wrecked here this morning; the fireman was killed outright and the engineer was badly bruised about his face and head. The wreck was caused by the removal of fishplates from the rails, and it is said to have been done by strikers.

Mobile, Ala., July 17.—There was a rear-end collision between two freight trains on the Louisville & Nashville Railroad to-night, and the fireman had his leg crushed so that amputation was necessary.

Oakland, N. J., July 17.—A rear end collision occurred by a passenger train running into a freight on the New York, Susquehanna & Western Railroad to-night. Engineer John Beatty was painfully injured by splinters of wood striking him in the face.

Clinton, Ind, July 18.—An engineer on the switching engine ran into a lot of coal cars on the Chicago & Eastern Illinois Railroad to-day. The fireman was the only one hurt.

Esperance, N. Y., July 19.—An express train on the Delaware & Hudson Canal Company's Railway ran into an open switch here to-day, striking several box cars on the side track. Fireman Palmer was killed and Engineer Truman Austin was fatally injured.

Macon, Ga., July 20.—A head-end collision occurred between a passenger and a freight train at Dame's Ferry on the East Tennessee, Virginia & Georgia Railroad here to-night. Fireman Pat Rogers and Doyle Thorn, engineer, were killed.

Leadville, Col., July 21.—While rounding a short curve here this morning Edward Malloy, a fireman on the Colorado Midland Railway, was thrown from his engine. His skull was fractured, and he was otherwise fatally injured.

Colorado Springs, Col., July 21.—A passenger train on the Atchison, Topeka & Santa Fé Railroad ran into a steer this morning; the engineer and fireman jumped and were slightly injured.

Norwich, Conn., July 22.—Dwight Beebe, fireman on a freight train of the New York & New England Railroad, was struck by another train to-day. His left hand was severed, his skull fractured and right arm broken; he died shortly afterward.

Texarkana, Tex., July 23.—There was a collision on the Texas Pacific Railway between two fast trains this morning. Edward Grimm, an engineer, and Allen, a fireman, were killed.

Sandusky, O., July 23.—A passenger train on the Colorado, Sandusky & Hocking Railroad collided with a switch engine to-day. John Van Horn, engineer of the passenger train, was killed.

North Bend, O., July 23.—The Chicago Express on the Big Four collided with a freight train at Griffiths this morning. The fireman of the freight engine was killed, and Engineer Differ, of the freight engine, was badly injured, as was also Frank Driver, engineer, and a fireman named Lampier.

Hantsport, N. S., July 23.—A collision occurred on the Windsor & Annapolis Railway between an excursion train and the special. Fred. Miller, an engineer, was injured in jumping from the engine, he had his face cut, his nose broken; fireman McNair was cut about the face and slightly injured about the head and shoulders.

Lima, O., July 23.—An attempt was made to wreck the pay train on the Cincinnati, Hamilton & Dayton Road to-day. The engine was partly wrecked and engineer Sweetman and fireman Kirchner badly injured. The work was done by running freight cars down on the main track.

Dunkirk, N. Y., July 23.—A special on the Dunkirk, Allegheny Valley & Pittsburgh Railroad ran into an open switch at Fredonia to-night and was wrecked. Fireman Keppell and Engineer Kimball jumped, the fireman sustaining serious injuries, while the engineer escaped with a sprained ankle and slight bruises.

White Cloud, Kan., July 24.—A freight train on the Chicago, Burlington & Quincy Railroad ran into a landslide at Gibraltar to-day. The engine tipped over and the engineer was slightly injured by having his fingers cut.

Pittsburgh Pa., July 25.—Spreading of the rails in the yards of the Edgar Thompson Steel Works at Braddock caused an engine and cars belonging to the Carnegie Company to be derailed. Fireman McCauley and Engineer John McCauley were seriously injured.

Lafayette, Ind., July 26.—A collision occurred between two trains on the Wabash Railroad 4 miles from here to-night. Engineer Clarke and Fireman Brown jumped; the engineer was fatally injured, the fireman seriously.

Ashland, Wis., July 27.—The relief train on the Wisconsin Central Road for the sufferers of the forest fires was burned to-day. Both engineer and fireman were injured.

Portage, Wis., July 27.—A passenger train on the Wisconsin Railroad collided with a switch engine here to-day. Engineer O. L. Blanchard was badly bruised.

St. Paul, Minn., July 27.—A freight transfer on the Chicago, Milwaukee & St. Paul Railroad was side-tracked near Mendotta to-night. The engineer and fireman were immediately attacked by strikers, though neither were seriously hurt.

Dansville, Ill., July 28.—Jo Burns, an engineer on the Chicago & Eastern Illinois Railroad, was shot this afternoon by strikers. He was shot through the lungs, and died from the effects of the wound.

Columbus, O., July 28.—Two Hocking Valley engines collided on account of a misplaced switch to-night Engineer Thomas Burke was caught and badly injured.

Chattanooga, Tenn., July 29.—Engineer John Lynch, on the Queen & Crescent Line, saw an open switch just ahead of him while running a fast mail train to-night; he stuck to his train and saved it. The fireman jumped and was badly injured. The switch was misplaced by train wreckers.

Cincinnati, O., July 30.—An express train on the Baltimore & Ohio Southwestern ran into a freight train 2 miles west of Aurora, Ind., this afternoon. The engineer and fireman of the passenger train were killed.

Cochran, Ind., July 30.—An express train on the Ohio and Mississippi Railway ran into a freight train here to-night. John Little, engineer of the passenger train, was fatally injured; Daniel Cadden was also caught in the wreck and lost a leg.

Ithaca, N. Y., July 30.—A loaded coal train on the Lehigh Valley Railroad collided with a passenger train near here today. Engineer Hawkins was badly hurt and Fireman C. B. Minor instantly killed.

Columbus, O., July 30.—A serious freight wreck occurred in the Columbus, Hocking Valley & Toledo Yards to-day by a switch having been left open, causing two engines to jump the track. Tom Burke, one of the engineers, was painfully injured.

Field, B. C., July 30.—The boiler of the locomotive on the Canadian Pacific Railway freight train exploded on a grade near here to-night. Engineer Wheatley and Fireman Hunt were killed.

Our report for July, it will be seen, includes 50 accidents, in which 21 engineers and 15 firemen were killed, and 25 engineers and 25 firemen were injured. The causes of the accidents may be classified as follows:

Boiler explosion	1
Cattle on track	2
Collisions	19
Derailments	1
Falling from engine	1

Killed by strikers	2
Landslide	1
Misplaced switch	6
Obstruction on track	2
Rails spreading	1
Struck by train	1
Train burned	1
Train wreckers	9
Trestle burned	1
Unknown	2
Total	50

PROCEEDINGS OF SOCIETIES.

Association of Engineers of Virginia, at the midsummer meeting, held on July 14, Mr. Staples gave a talk on the construction of the canals connecting the head waters of the Wisconsin and those of the Illinois rivers. The special feature of the work is the entire use of concrete masonry in the walls, locks, etc., which were put in at a cost averaging about $8 per yard.

Master Car & Locomotive Painters' Association.—The twenty-fifth annual convention of the Master Car & Locomotive Painters' Association will be held at Buffalo, N. Y., on the 12th, 13th and 14th of this month, convening at 10 o'clock A.M., on Wednesday the 12th. The headquarters of the Association will be at the Genesee Hotel, where thorough arrangements have been made for all in attendance. The following are the lists of subjects that will be presented in the papers and discussed: 1. What is the best method of keeping accounts in the paint shop? Labor and material? 2. What methods and materials produce best results in repainting passenger cars that are badly cracked, and is there any method by which cracks in old paint can be obliterated without burning off? 3. In adopting a classification of repairs to passenger cars, what are the various conditions of the paint or surface that should determine the class of repairs, or what standard can be adopted by which to determine when the condition of the paint requires a certain class of repairs? 4. An essay on Painting Passenger Cars, in the form of questions and answers. 5. What is the best method of computation and establishing rates for piece-work on the different classes of painting repairs for passenger equipment cars? 6. What is the best method of computation and establishing rates for piece-work on the different classes of painting repairs for locomotives? 7. What is the best method to adopt to insure the proper care of and prevent loss of paint shop tools—namely, brushes, chamois skins, sponges, dusters, buckets, cups, etc.? 8. What advantages if any are there in using ready prepared primers and surfacers on cars and locomotives in preference to those prepared from our own formulas, convenience, time and durability considered? 9. What primers and surfacers, or formulas for the same, which do not contain white lead, have proven satisfactory substitutes for lead primers and surfacers on the outside of passenger cars and locomotives? 10. What style of finish in the construction of passenger equipment cars is the most desirable from a painter's standpoint—namely, the easiest painted or cleaned and kept in repair, durability and economy considered? The panel sliding with battens, or a 2 or 2½-in. beaded or tongue and groove sliding.

PERSONALS.

The following appointments have recently been made on the Great Northern Railway Line: Mr. C. H. Jenks, Superintendent Northern Division, vice C. C. Ponsonby, transferred. Mr. O. O. Winter, Superintendent Willmar Division. Mr. Winter will also continue in charge of the Breckenridge Division as Acting Superintendent until further notice. Mr. C. H. Cannon is hereby appointed Superintendent of Car Service.

Mr. D. McLaren is appointed General Superintendent of the Montana Central Railway and operated lines.

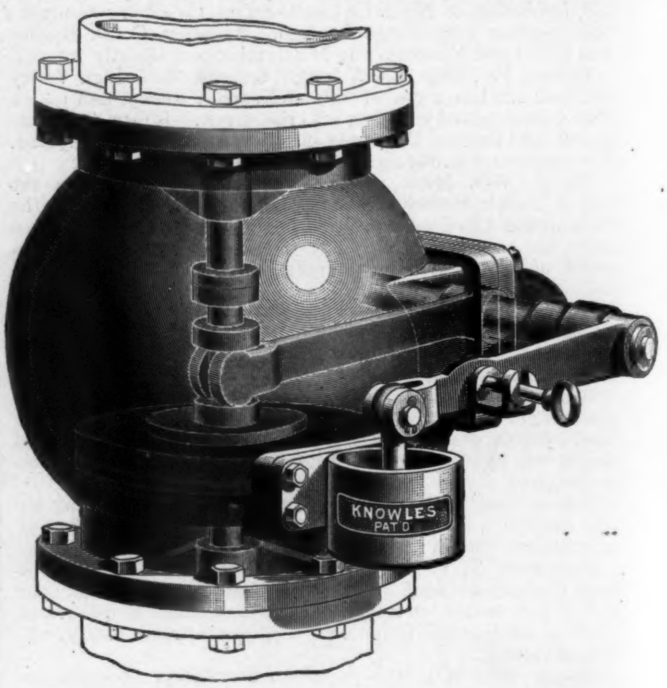
Mr. R. W. Bryan having resigned, the following appointments are made, in effect August 15, 1894: Mr. E. W. McKenna, General Superintendent Eastern District. Mr. J. D. Farrell, General Superintendent Western District.

E. L. Corthell announces that he has removed his offices to No. 71 Broadway, New York.

Manufactures.

THE KNOWLES AUTOMATIC EXHAUST RELIEF VALVE.

The valve shown by the accompanying engraving is one of the latest improvements applied to an engine and its condenser. It is intended to be placed in a branch leading from the main exhaust pipe to the atmosphere. The application of this valve is very necessary to an engine whose stoppage caused by failure of the vacuum in the condenser would meet with serious results. Sometimes through air leaks, accident to the air pump or the cessation of the injection water supply, the exhaust steam from the engine accumulates in the condenser and exhaust pipe, increasing the pressure and shortly stopping the engine. Also the hot steam passing into the air pump destroys the rubber valves and removes the load from the air pump, causing it to race and do serious damage. To prevent this and give the accumulated steam free admission to the atmosphere, the Knowles automatic exhaust relief valve was designed. The valve proper is practically a check valve composed of a material unaffected by steam heat and fitting perfectly air-tight on a brass seat contained within a cast iron spherical chamber. This valve remains seated and perfectly inactive as long as the engine is running with a vacuum, but as soon as this is lost, due to the above reasons, the pressure in the exhaust pipe immediately opens the relief valve, allowing the engine to run non-condensing. When the condensing apparatus is again in working order and the vacuum obtained,

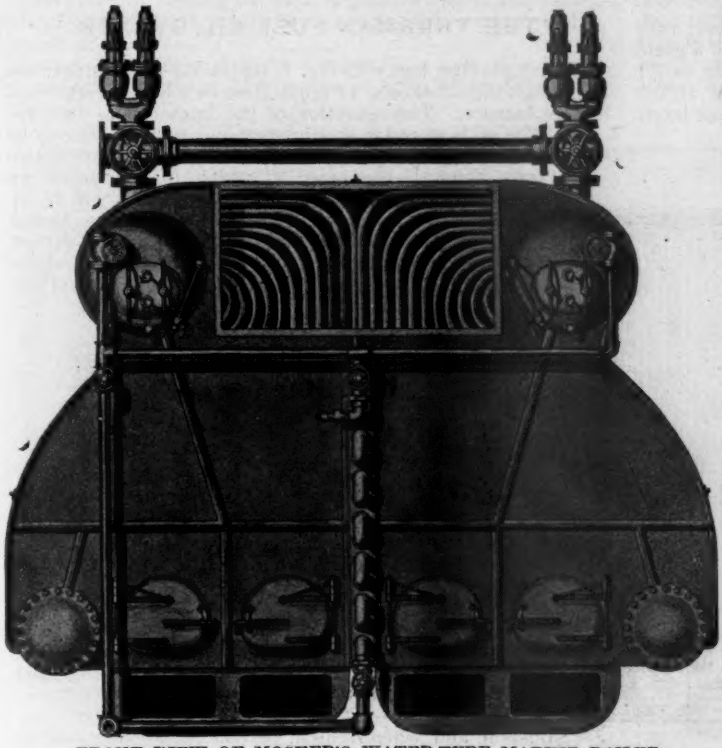


the valve closes automatically without shock or jar. At first thought it would seem as if an ordinary check valve would answer the same purpose, but this would soon hammer itself out of shape from the intermittent action of the engine's exhaust, and allow the air to enter and spoil the vacuum. To prevent this pounding and save wear and tear on the valve, a dash pot is provided, whose piston is connected by a double lever to the valve, and moving simultaneously with it. In the bottom of the dash pot cylinder is a small hole covered by a valve opening to the interior of the cylinder. As soon as the main valve rises the piston follows, allowing the air to enter the cylinder through the small valve. When the vacuum is again obtained, the atmospheric pressure forces the main valve back on its seat, thereby compressing the air in the dash pot, which, on account of the closure of the small valve, slowly escapes between the piston and cylinder, allowing the main valve to seat itself without shock or jar. This valve offers little or no obstruction to the exhaust steam in case the engine is to run non condensing, and can be held wide open for this purpose by an attachment shown on the engraving.

These valves are manufactured in various sizes to suit all requirements, and are for sale by the Knowles Steam Pump Works, 93 Liberty Street, New York.

MOSHER WATER-TUBE BOILER.

In the designing of a water-tube boiler for marine work it is necessary that it should be so arranged that it will occupy the least possible space and at the same time have its parts so related to each other that the expansion and contraction of the heated metals have the chance for a free movement. All of the generating parts should be of so small a diameter that in case any of them should be ruptured it will not necessarily involve a disaster. Circulation should be provided for so that not only the water will pass freely from the cooler to the more heated portions of the boiler, but that the steam should have an opportunity to liberate itself freely from the water. It is also very desirable that the passage of gases in going from the fire to the stack should move as nearly as possible at right angles to the heating surfaces. The feed water should not come in contact with the boiler plates, and ample facilities should be provided for cleaning the tubes and other parts. In addition to the above the boiler should show an economical efficiency in working condition



FRONT VIEW OF MOSHER'S WATER-TUBE MARINE BOILER.

The boiler which we illustrate in this connection is one that has been designed by Mr. C. D. Mosher, and has been applied to the fast yachts *Feiseen* and *Norwood*, which have a record of 31.06 miles and 30.5 miles respectively. They also have been used in more than half of the torpedo boats of the United States Navy.

Fig. 1 is a cross-sectional elevation of a boiler, showing the general construction; from this it will be seen that the boiler consists of two practically independent boilers, either one of which can be used separately and independently of the other. The brick wall which rises between the two grates carries a coil of pipe through which water is made to circulate. These pipes are connected at each end by return bends and absorb a large portion of the heat existing in the brick wall, thus greatly increasing the durability of the latter. The generating tubes start from the upper portion of the water drum and are open to form the sides and top of the furnace; they are then bent upward and outward to where they connect the upper portion of the water drum.

They extend the full length of the drums, and are bent so as to form a wall protecting the casing from the heat of the furnace; these tubes are spaced their own diameter apart, longitudinally, but in staggered rows, where they enter the steam and water drums. While in the circumferential rows they are spaced a somewhat greater distance apart. In this way the lower rows of tubes are so bent and interlocked with one another that they form a solid wall over and along the sides of the furnace, as shown in the sectional plan, fig. 3. The same thing is done with the outward tubes, forming a similar wall along and under the whole length of the boiler, as shown in fig. 3. The back portion of the inner row of tubes, however, is left staggered for the passage of gases, as is also shown in fig. 3. Fig. 2 is a longitudinal section of the boiler with the brick wall removed, showing the passage of gases. It will be seen that just forward of the center of the boiler there is a baffle plate extending down from the top, beneath which the gases must pass on their way to the stack; the object of this is to cause the gases to come more intermediately in contact with the tubes that are filled with solid water.

Circulation takes place down through the outward rows of tubes to the water drum and up through the generating tubes, where it is converted into steam and delivered above the water-line into the steam drum against a baffle plate under which the steam is caused to flow thence through the separators shown in fig. 1, where any entrained water is removed before entering the steam pipes.

The separator consists of a spiral tube, as shown in fig. 1, made of sheet metal, with the edges overlapping and forming a slot which opens downward. This tube extends nearly the full length of the steam drum, and contains a worm. One end is attached to the steam pipe, while the other is left open.

A perforated hood surrounds the upper portion of this tube, and the lower portion forms a trap extending only a short distance in length, while the upper portion extends somewhat beyond the enclosed tube, both ends of the hood being closed, one end allowing the tube to pass through it where it is attached to the steam pipe.

In action the steam or vapor enters the perforations, which extend the whole length of the top side of the hood, and passes back through the space between the hood and the tube, then enters the end of the slotted tube, where the steam is caused to take a rotary motion by the worm or auger-formed screw, the centrifugal motion thereby created causing the water to be thrown to the outside, where the overlapping lips of the tube catch any entrained water and deliver it to the trap below, where it overflows. It will be seen that this separator really consists of several separators contained in one, as each convolution of the worm, in combination with the overlapping edges of the tube, forms a separator of itself. A special feature of this separator, wherein it differs from all others, is that, after

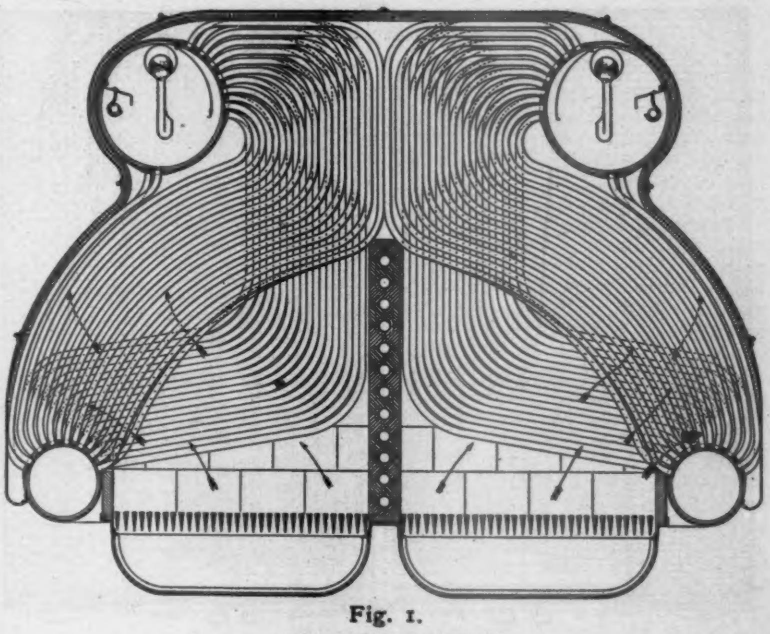


Fig. 1.

TRANSVERSE SECTION.

the separation has once taken place, the water of separation does not again come in contact with the currents of steam.

One advantage claimed for this boiler is the independence of the two halves, so that, should one half be injured by a shot, the other, by continuing to work, gives the vessel an opportunity to escape. The center of gravity is very low, which is a feature which will be appreciated in marine boilers.

In some tests made with these boilers on an 8-hour run, where there was 1,100 sq. ft. of heating surface, with a grate area of 33 sq. ft., 235 lbs. of coal were burned per hour, or 7.1 lbs. per square foot of grate. The water evaporated at 185 lbs. pressure from 73° F. was at the rate of 2,143 lbs. per hour.

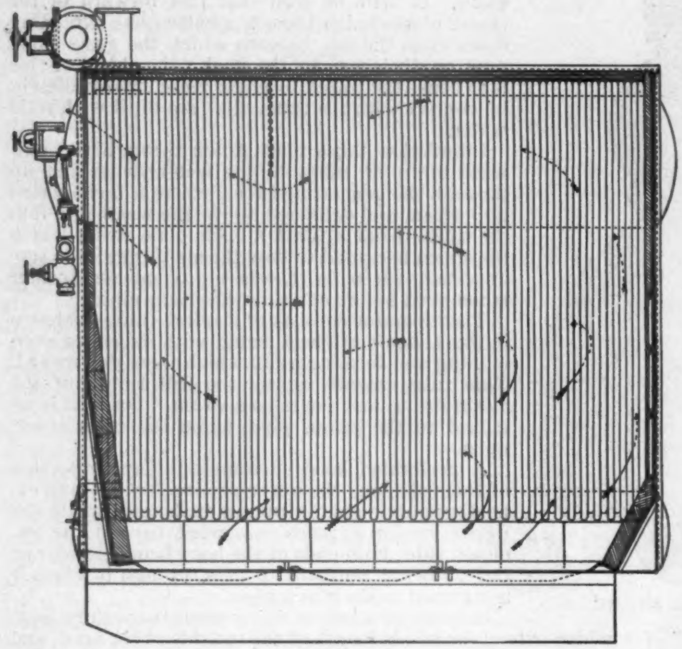


Fig. 2.

LONGITUDINAL SECTION (FIRE-BRICK WALL REMOVED).

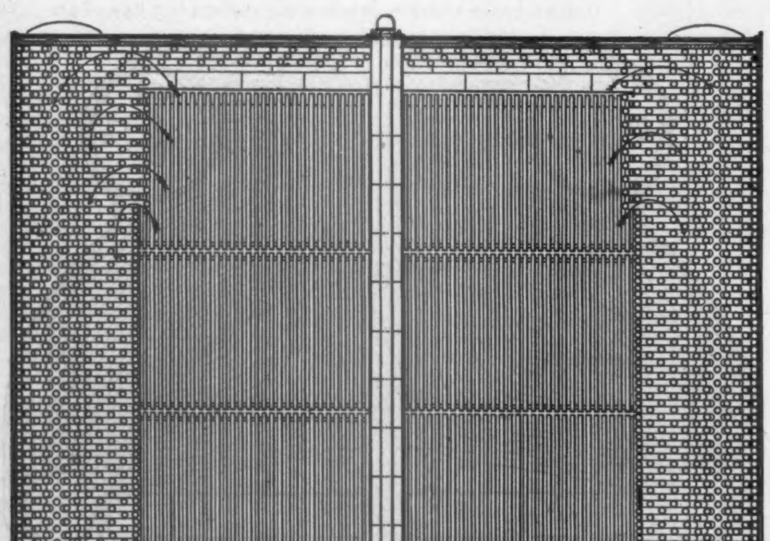


Fig. 3.

SECTIONAL PLAN.

The temperature in the stack was 443° F. and the water evaporated per pound of coal was 912 lbs.; reducing this to water evaporated per pound of coal and at 212°, we have 10.92 lbs. per pound of coal, or 11.07 lbs. per pound of combustible. This figures out that the useful effect or efficiency of evaporated water is 76 per cent.

Boilers of this type are now being built for several vessels, one of which is guaranteed to be a record breaker, and is being constructed by the builders of the *Yankee Doodle*.

THE THURMAN FUEL OIL BURNER.

Our engraving herewith (fig. 1) represents this burner, and the sketch (fig. 2) shows its application to a boiler, forges and a glass furnace. The operation of the burner is as follows: The oil is stored in an underground tank, *D*, shown by dotted lines in fig. 2. Compressed air is carried to this tank through the pipe *B*, which forces the oil up through the pipe *C* to the burners *F F F*. Oil is admitted to the burner, shown in fig. 1 by a pipe, *M*, and steam or compressed air by the pipe *N*. The stream of oil and stream of air mingle in the burner, and the oil is thus thoroughly "atomized." A stream of hot

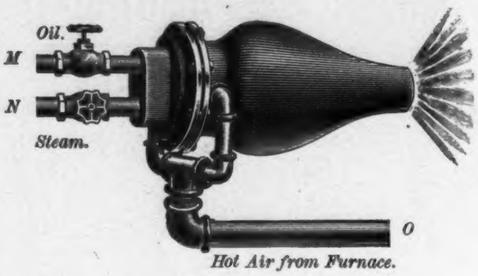


Fig. 1.

air is also conducted to the burner by the pipe *O*. This hot air is intimately mingled with the atomized oil, and escapes from the mouth of the burner into the furnace, and then contains within itself all the elements of combustion, and when lighted, perfect combustion results, and continues uninterruptedly so long as the mingled stream of atomized oil and air is delivered into the furnace.

In fig. 2 *A* is the air compressor. Through pipe *B* the compressed air presses on the surface of the oil in tank *D*, forcing the oil through the pipe *C* direct to the burners *F F F*, where it is met by the pressure of air from the same source of power. *N N N N* is the hot-air pipe from furnace. The proportions of oil are regulated by the burner valves *K K K K*, and proportions of air are regulated by the valves *J J J J*. The burner under the boiler *M* can be operated by either air or steam. *L* is the steam valve, *P* is the inlet to tank and *R* is the vent. The air pressure thoroughly atomizes the oil, and the oil atoms and air atoms intimately commingle with the hot-air atoms from the furnace, and pass from the mouth of the burner in a highly combustible and vaporous form with perfect combustion. In this system steam can be substituted to atomize the oil instead of air by substituting an oil pump and stand pipe instead of the air compressor and receiver.

This system of burning crude oil is adapted to all classes of work, such as boilers, reverberatory furnaces of all kinds. Copper and brass, it is said, are melted in crucibles at one-half the cost of coal, and the crucibles are more permanent. Puddling, forges, dryers of all descriptions. Glass making and working are successfully accomplished with large savings in fuel. Burning brick, tile and pottery of all kinds. The burners generate pure hydro-carbon gas, and wherever used every unit of heat the oil contains is utilized and applied without any expensive intermediate process of treatment.

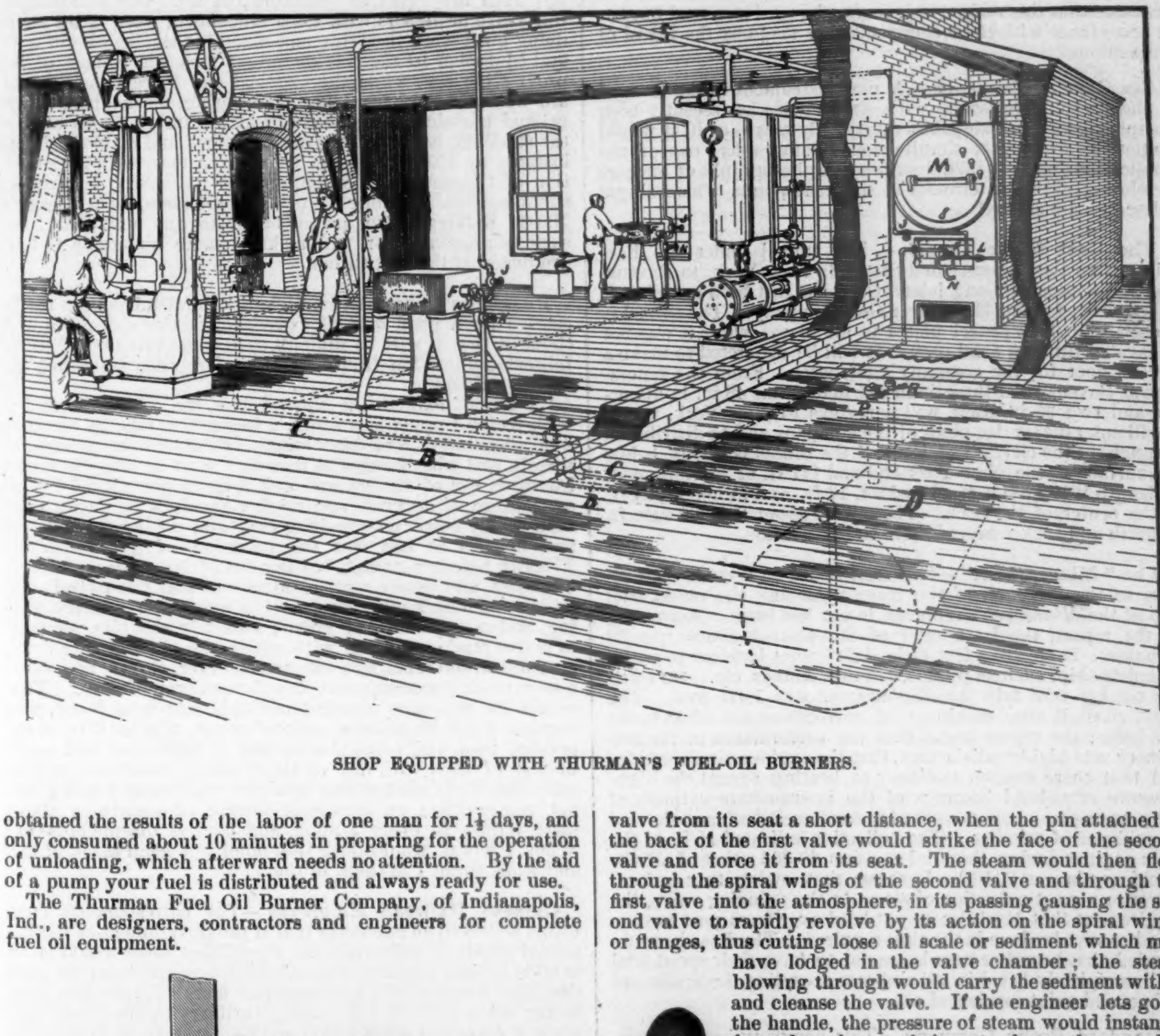
The numerous advantages of oil over coal for fuel will readily be appreciated from the following facts: It diminishes the expense of handling coal. It costs at least 5 cents per ton to unload it, providing you have a switch to your bins, before it is distributed about the plant. There is a shrinkage of 5 per cent. in weight, and about the same in waste by

handling. It is an impossibility to burn and not consume a certain amount of coal from which no benefit is derived, caused by the necessity of opening the doors, and cold air rushes in, causing an immediate and reverse change to take place, while with oil, if your fires are too hot, turn a valve, save your fuel.

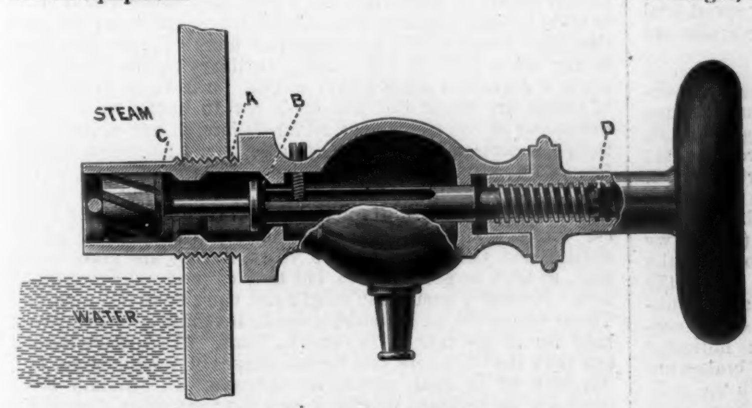
The labor of feeding the fires, clinkering the boxes, taking care of ashes and the wear on boilers, kilns are not needed in the use of oil.

One car of oil is said to be equal to three cars of coal, and by attaching a rubber hose or gas-pipe, in 2 hours you have obtained the results of the labor of one man for 1½ days, and only consumed about 10 minutes in preparing for the operation of unloading, which afterward needs no attention. By the aid of a pump your fuel is distributed and always ready for use.

The Thurman Fuel Oil Burner Company, of Indianapolis, Ind., are designers, contractors and engineers for complete fuel oil equipment.



SHOP EQUIPPED WITH THURMAN'S FUEL-OIL BURNERS.



ASHLEY'S AUTOMATIC GAUGE-COCK.

ASHLEY'S SAFETY AUTOMATIC GAUGE-COCK.

THIS gauge-cock is especially adapted to locomotive and portable boilers, as will appear from the description. It screws into the boiler or water column, as shown in the engraving. The sectional view shows two valves, and two valve seats in the cock, one behind the other, and one of which is cast in one piece with the central stem as shown, having a pin projecting from its center, designed to strike against the face of the second valve.

The operation is as follows: Steam being on the boiler, the pressure would force both valves to their seats as shown. To open the valve, turn the handle—which is attached to the sleeve outside of the screw—from right to left, which will unscrew on the central stem; then by pushing the handle in toward the boiler, the central stem would slide inward, forcing the first valve from its seat a short distance, when the pin attached to the back of the first valve would strike the face of the second valve and force it from its seat. The steam would then flow through the spiral wings of the second valve and through the first valve into the atmosphere, in its passing causing the second valve to rapidly revolve by its action on the spiral wings or flanges, thus cutting loose all scale or sediment which may have lodged in the valve chamber; the steam blowing through would carry the sediment with it and cleanse the valve. If the engineer lets go of the handle, the pressure of steam would instantly force the valves to their seats; but as the second or flanged valve comes to its seat a little before the first valve, and as it is being rapidly rotated by the action of the steam on its flanges, it strikes the seat while revolving and regrinds the valve seat slightly each time the valves are closed. The next feature is the arrangement of the second valve and its seat. Suppose the gauge-cock should be broken off of the boiler in a collision or by a blow, it would of course break just outside of the boiler sheet, the weakest part, which would leave the second valve, which is within the boiler, closed, and consequently the engineer would not be scalded; and if it should happen when his engine was running, he would not have to stop his engine, as he would otherwise be forced to do. The screw 2 fits into the groove of the central stem and keeps the stem from revolving. After the valves have automatically closed by the pressure of steam, the engineer can screw up the handle which would draw the first valve to its seat, and it could not be accidentally forced open by being pressed against. Manufactured and for sale by Frank M. Ashley, M.E., 136 Liberty Street, New York City

NOTES.

A Correction.—Owing to a typographical error, the price of oil tallow and waste for the Flint & Père Marquette Railroad was placed at 1.63 cents per mile in our locomotive returns for April. It should have been 0.163 cent. This includes illuminating and lubricating oils and waste.

The "New York."—Since a recent examination of the cruiser *New York* has been made it has been decided that the midship ammunition-room is too near the boilers, and it is probable that this room will hereafter be used as a coal bunker in accordance with the recommendation made by the Board of Inspection.

Six-Camera Telescope.—A new instrument in the form of a photographic telescope with six cameras has recently been completed for the Yale Observatory. By means of it, it would be possible to take six simultaneous photographs; one of the applications being to take simultaneous photographs of meteors by closing electrical circuits at different points where single telescopes are erected.

The East River Tunnel. — The tunnel under the East River from East Seventy-first Street, in New York, to Ravenswood, a section of Long Island City, has just been completed. It was built for the East River Gas Company. The tunnel is arched with heavy steel plates in all places where it was not excavated through solid rock. It will be concreted to make a perfect floor for the company's purposes. From the generators at Ravenswood three immense mains, one 48 in. in diameter and two 36 in. each, will carry gas to New York, where it will enter the service pipes of the company and be distributed throughout the city. The level of the tunnel is 135 ft. below the surface at the New York end and 147 ft. at Ravenswood. In length it is 2,541.4 ft.; in width, 10 ft., and in height, 8½ ft. in the center of the arch. There were about 216,000 cub. ft. of earth and rock removed from the excavation.

The "Minneapolis."—The Trial Board have made their report to the Secretary of the Navy regarding the recent trial trip of the *Minneapolis* reported in our last issue. According to the report, the least water of the 44-knot course was 30 fathoms. There are a few little deficiencies incident to an incomplete ship, such as pumps, cellulose fillings, etc. On starting on her trial trip the displacement was 7,475 tons. The speed attained after making tidal corrections was 23.53 knots per hour; the report states that the performance of the machinery was highly satisfactory, that the engines ran smoothly, and that there was no tendency to heating except the high-pressure cross-head bearings of the intermediate cylinder of the port engine; boilers worked under forced draft and showed no evidence of priming. The collective indicated H.P. of the main engines during the trial run was 20,366; that of all the machinery in use, 20,812. It seems that, owing to a lack of power or a great reduction of steam by the reducing valve, the requirement that the helm be put hard over from port to starboard cannot be done in the time required. The Board recommended that hereafter vessels are not to have their speed trial until completely fitted in all respects excepting the armament fittings and paint inside and out.

Standard Brake Company.—This company has been perfecting a new triple valve for air brakes that does not infringe on any other patents and that is perfectly interchangeable with those now in use. It has also these valuable improvements: 1. It will release the brakes on long trains with certainty. 2. The auxiliary reservoirs can be recharged while the brakes are still applied as well as while they are off. 3. By the addition of one part to the above-mentioned triple valve (which we have named the "accelerator") we are enabled to apply the brakes much more quickly than is done at present. While the "accelerator" forms a part of the triple valve, it is also manufactured separately, so that it can be attached to other compressed air-brake systems. This company has sent us indicator diagrams showing that with their accelerator the brakes are applied very much more quickly than they are with the ordinary triple valve. Mr. Dudley, in his report to the New York Central & Hudson River Railroad Company on the air-brake tests made by him two years ago, states that it is more difficult now to decrease the time of application of the brakes on a 50-car train by $\frac{1}{10}$ second than it was some years ago to decrease it from 10 seconds to 3½, as Mr. Westinghouse did when he invented his "quick-action" device.

University of California.—This free university was incorporated by the Legislature of California in 1868. The United States gave the State land valued at $2,500,000, of which over $2,000,000 in value have been sold and invested, the interest upon which is annually applied toward the expenses of this university, which has colleges of letters (classical and literary courses), agriculture, mechanics, mining, civil engineering and chemistry, all located at Berkeley. The colleges of law, dentistry, medicine and pharmacy, and the Mark Hopkins Art Institute are located in San Francisco, and the Lick Astronomical Department is located at Mount Hamilton.

The location at Berkeley is unsurpassed, and the buildings and grounds first-class and ample. The library and Bacon Art Hall are gems of literature and art. One hundred and thirty-five professors with 1,400 students of both sexes are all doing good work in giving and obtaining the benefits of a liberal education to the coming bright men and women of this progressive age, while the classical and literary departments are well provided for. The engineering, mechanical, electrical and chemical departments, which number 35 per cent. of the students, have recently been enlarged and endowed in one instance by $400,000 in one bequest, so that, with the exception of Chicago and Cornell, no free university in America surpasses this. Its long list of able professors, from President Martin Kellogg down, are an honor to any university, and each succeeding year will make it more honorable to have graduated at this institution.

Ruskin on Locomotives.—The locomotive has been the incentive for a good deal of extraordinary eloquence, but it is thought that it will be difficult to find anything equal to the following quotation from a volume of recently published lectures by Ruskin:

"I cannot express the amazed awe, the crushed humility, with which I sometimes watch a locomotive take its breath at a railway station, and think what work there is in its bars and wheels, and what manner of men they must be who dig brown ironstone out of the ground and forge it into THAT! What assemblage of accurate and mighty faculties in them; more than fleshly power over melting crag and coiling fire, fettered and finessed at last into the precision of watch-making; Titanian hammer-strokes, beating out of lava these glittering cylinders, and timely respondent valves, and fine-ribbed rods, which touch each other as a serpent writhes in noiseless gliding, and omnipotence of grasp; infinitely complex anatomy of active steel, compared with which the skeleton of a living creature would seem, to a careless observer, clumsy and vile—a mere morbid secretion and phosphatous prop of flesh. What would the men who thought out this, who beat it out, who touched it into its polished calm of power, who set it to its appointed task and triumphantly saw it fulfill this task to the utmost of their will, feel or think about this weak hand of mine, timidly leading a little strain of water-color which I cannot manage, into an imperfect shadow of something else—mere failure in every motion, and endless disappointment? What, I repeat, would these iron-dominant genii think of me, and what ought I to think of them?"

Chinese Railroad Employés.—The correspondent from China writes to an exchange that if the Government at Peking should decide to build roads all over China there would be no trouble in their construction, and the wages and labor are such that they could be laid and equipped more cheaply here than in any other part of the world. Ordinary coolie labor costs about 8 American cents a day, and the farm wages in this part of China are about 4 of our cents for 10 hours' work. The brakemen on the trains get 6 silver dollars, or not much more than 3 American dollars, a month as wages; firemen receive from $5 to $10 in silver, and engineers get from 8 to 30 American dollars a month. The best engineers and the best workmen come from the south of China, and these receive the highest wages. The Cantonese engineers start in at 30 silver dollars, and they can rise in 9 years, if they are good workmen, as high as $60 a month, but they cannot make more than this. Northern men begin at $15 and can rise to $35 a month. These wages are for 60 hours a week, anything over that being paid for at the rate of 15 cents an hour. Conductors receive less than the engineers, and certain classes of workmen get two Sundays off in each month as holidays. In ordinary labor there are no holidays in China, and the contractor expects his hands to work Sunday and every day, except a week or so at the Chinese new year. In the works here there are a great number of blacksmiths, carpenters and miners employed. The northern carpenters get from 5 to 8 silver dollars, and Canton carpenters receive from $20 to $30 a month. Blacksmiths get all the way from 5 to 40 silver dollars a month, and the wages of miners are 18 cents a day. At such wages skilled men can be gotten by the thousands in any part of China, and the building of railroads is merely a matter of decision on the

part of the Government that they shall be built, and of the little time and comparatively little money required to make them.

The French Battleship "Le Carnot."—The great French battleship, which was laid down at the Arsenal of Le Mourillon, Toulon, in July, 1891, as the *Lazare Carnot*, but which henceforth, in memory of the assassinated President as well as of his grandfather, is to be called *Le Carnot*, was launched on Thursday, July 12. She is practically a sister ship to the *Charles Martel*, which was launched at Brest on August 28, 1893. The length of the vessel is 396 ft., her beam 71 ft., her draft aft 27½ ft., and her displacement 11,882 tons. She has a complete steel belt with a *maximum* thickness of 17.7 in., and a curved steel deck 2.75 in. thick. Above the water-line belt there rises for an additional height of 4 ft. a steel belt of 4-in. armor. The machinery of the ship consists of a pair of compound vertical engines with three cylinders, fed by 24 Lagrafelle and D'Allest boilers. At 95 revolutions, with forced draft, 13,500 H.P. should be developed, giving a speed of 18 knots, and with 85 revolutions, with natural draft, 9,500 H.P., giving a speed of about 17 knots. The machinery weighs 1,178 tons. The normal coal capacity is 800 tons, or enough for 4,000 knots' steaming, but when all subsidiary bunkers are full, coal for 5,000 knots can be carried. The cost of *Le Carnot* will be, for the ship, £960,000; for her gun and torpedo armament, £104,000; and for machinery and boilers, £127,200, or, in all, £1,191,200. The armament will consist of two 11.8-in guns, one in a 14.6-in. turret forward and the other in a similar turret aft, the forward gun being 26 ft. and the after gun 19.5 ft. above the water line; two 10.6-in. guns, one in a 14 6-in. turret on each beam, eight 5.5-in. quick-firing guns, mounted singly in 3.9-in. turrets, four on each beam; four 2.5-in. quick-firing; twelve 1.8-in. quick-firing, and eight 1.45-in. quick-firing or Maxim automatic guns. There will also be four above-water and two submerged torpedo-launching tubes. The most significant feature of the vessel is the enormous power of her right ahead and right astern fire. In each case this is furnished by one 11.8-in., two 10.6 in. and four 5.5-in., besides smaller guns. Beam fire is furnished by two 11.8-in., one 10.6 in and four 5.5-in. guns, so that in every direction the ship is offensively strong to an exceptional degree. In this respect we have nothing that can compare with her.

Recent Patents.

WIGHTMAN'S STARTING APPLIANCE FOR COMPOUND ENGINES.

"The object of my invention is to provide simple and effective means for positively actuating the converting valve mechanism of a compound machine, either by fluid pressure or by manually applied power as desired, in order to enable the engineer to operate the engine as a simple or non-compound engine, whenever and during such periods—of any desired length—it may become necessary, or be deemed advisable, to so operate it, as when starting a train or ascending a long and heavy grade, and to immediately reinstate it in normal operation as a compound engine when the conditions are such as to make compound operation proper or desirable.

"This invention consists in the combination of a fluid pressure cylinder, a piston working therein, a valve operating rod connected to said piston and to a converting valve mechanism, a distribution valve controlling the action of motive fluid upon said piston, a stem connected to said distribution valve and connections for positively actuating said stem by the reversing gear of a compound engine.

"My invention is more particularly designed for application in two cylinder compound locomotive engines, in which provision has heretofore been made for the direct admission of boiler steam to, and the independent exhaust of steam from, both cylinders of the engine in the manner of a simple or non-compound engine, when a temporary increase of power is required, as in a starting train. The converting valve mechanisms employed for this purpose, which are of various constructions, are adapted, in many instances, to be automatically operated by variations of pressure, and in others to be operated by hand through connections to a lever moved by the engineer. Inasmuch as it is desirable to avoid as far as possible the use of levers additional to those required in the normal operation of the engine as compound, starting valves have been actuated through connections to the ordinary reverse lever, as in the so-called Linder system and others; but it will be obvious that in such cases the friction and unbalanced pressure, if any, which resist the movement of the valve or valves actuated by the engineer, impose additional labor upon him in moving the reverse lever.

"Under my invention the converting valve mechanism is normally and ordinarily actuated by fluid pressure, which is applied by the engineer, preferably in and by the movement of the reverse lever, and the only additional manual power exerted by him is that required to effect a short traverse of a small distribution valve which is so slight as not to be appreciable. In the event of damage or derangement of any of the fluid pressure members of the appliance, the mere detachment of the bolt connecting the piston thereof with the rod which operates the converting valve mechanism, enables the latter to be operated by hand whenever desired.

"In the accompanying drawings, fig. 1 is a diagrammatic side view of a compound locomotive engine, illustrating an application of my invention; fig. 2, a side view in elevation, showing the fluid pressure cylinder, the reverse lever, and the intermediate connections from the reverse lever to the distribution valve; fig. 3, a view, partly in elevation and partly in section, and on an enlarged scale, of the fluid pressure cylinder, the distribution valve and its chest.

"In the practice of my invention, as applied in connection with a two-cylinder compound locomotive engine of the general type now employed in American railroad service, I provide a fluid pressure cylinder, 1, which may be, as shown, located within the cab 2 and secured to the side of the fire-box 5. The cylinder 1 is provided with a properly packed piston, 6, secured upon a rod, 7, which passes through a stuffing-box, 8, in one end of the cylinder. A valve-chest, 9, is formed upon or secured to the cylinder 1, and communicates therewith near each of its ends by induction and eduction passages 10 and 12 leading respectively to supply ports 13 and 14 in a valve face, 15, within the valve chest 9. A supply pipe, 16, leads into the valve chest above the valve face 15 from any suitable source of fluid pressure supply, being, in the instance shown, a chest, 17, communicating by a pipe, 18, with the dome 19 of the boiler, and an exhaust pipe, 20, leads from an exhaust port, 21, located in the valve face between the supply ports 13 and 14 to any convenient point of discharge, as, for example, the ash-pan, 22. It will, however, be obvious that in engines which are provided with an air-brake equipment, as is now generally the case, the supply pipe 16 may be readily connected with the main air reservoir or other suitable member of the air-brake apparatus, so as to admit of the employment of compressed air for the actuation of the piston 6 in lieu of steam, as in the specific construction shown; and such connection, which is preferable when facilities therefor are available, I include in my invention as the mechanical equivalent of that shown.

"The piston-rod 7 is connected by a detachable pin or bolt, 23, to a yoke, 29, and by rods 24ª to a valve operating rod 24, which extends toward the smoke-box 4 of the engine, and is coupled by suitable intermediate connections, in this instance a double armed lever, 25, and a link, 26, to the stem 11 of a converting valve mechanism of any suitable and approved construction, which is fitted to reciprocate in a chest in one of the saddle sections 3 on which the smoke-box 4 is supported and to which the cylinders of the engine are connected. The lever 25 is journaled on or by a pin, 27, and the relative lengths of its arms are such as may be proper to impart the desired range of reciprocating movement to the stem 11 and the converting valve mechanism connected thereto.

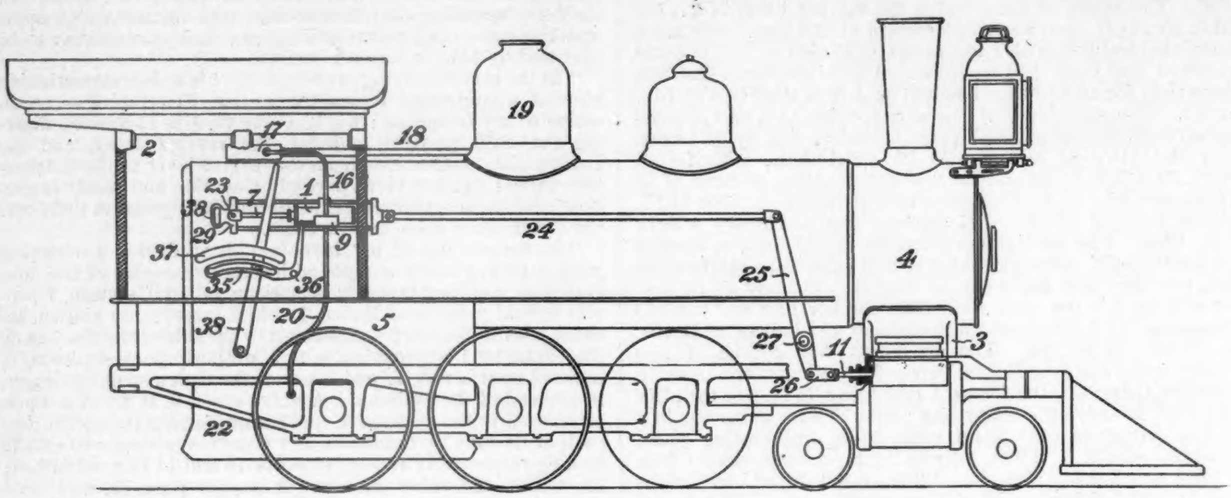
"Inasmuch as any suitable and preferred mechanism may be employed, and as the same does not in and of itself constitute part of my present invention, it will not be herein at length described.

"In order to insure the rectilineal movement of the valve operating-rod 24, said rod is, adjacent to the fluid pressure cylinder 1, bifurcated or fixed to two parallel guide rods 24ª, which pass through guides 28 on the cylinder 1, and are connected at their rear ends by a block, 29, which receives the connecting-pin or bolt 23 of the piston rod 7, and is provided with a handle, 38. In the event of the derangement or breakage of any member of the fluid pressure apparatus, or of the failure of supply thereto, the connecting-pin 23 may be detached and the rod 24 and connected converting valve mechanism be operated by the engineer by the application of manual power to the handle 38.

"The supply and exhaust of motive fluid to and from each end of the cylinder 1 are effected and controlled by a distribution valve, 30, which is preferably, as shown, of the short D slide type, and is fitted to be reciprocated on the valve face 15 of the chest 9. The stem 31 of the distribution valve passes through a packed stuffing-box, 32, in one end of the chest, and is normally actuated, through intermediate connections, by the reversing gear of the engine, said connections being so organ-

ized that when the reverse lever is moved to or near its full forward or its full backward position, the distribution valve 30 will be, in either case, and in and by such movement of the reverse lever, moved into the position shown in fig. 5, thereby admitting motive fluid on the rear side of the piston 6 and exhausting it from the front side thereof, while, in and by the movement of the reverse lever to any intermediate position, the distribution valve will be moved backward so as to uncover

FIG. I.

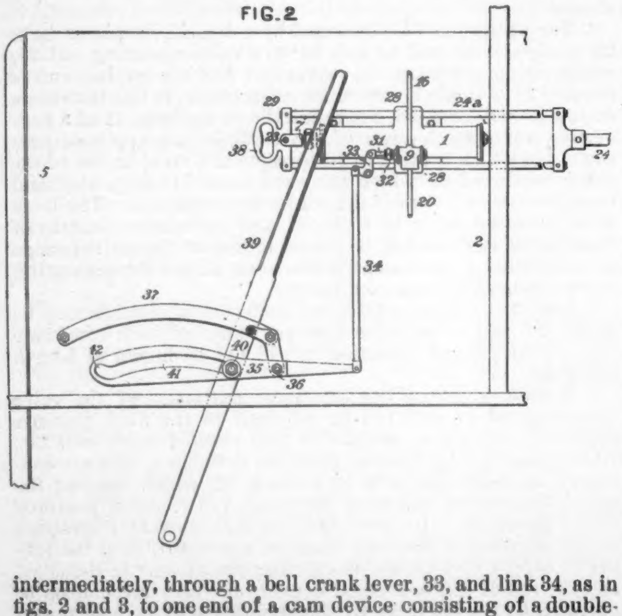


WIGHTMAN'S STARTING APPLIANCE FOR COMPOUND LOCOMOTIVES.

the forward supply port 13 and place the rear supply port 14 in communication with the exhaust port 21 through the exhaust recess of the valve, thereby admitting motive fluid on the front side of the piston 7 and exhausting it from the rear side thereof. The piston 7 will correspondingly be forced to and remain at the front or the rear end of the cylinder 1, and the converting valve mechanism be moved into position for the operation of the engine as a simple or as a compound engine, as the case may be.

"In the instance exemplified, the stem 31 of the distribution valve 30 is shown as coupled, either directly (as in fig. 1) or

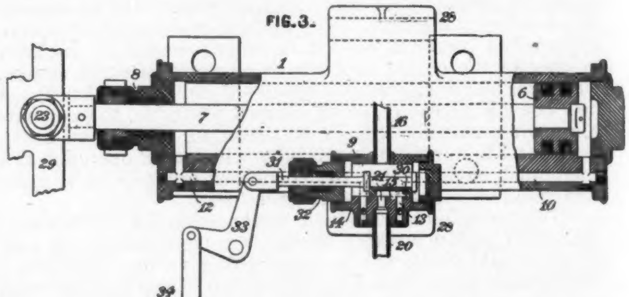
FIG. 2



intermediately, through a bell crank lever, 33, and link 34, as in figs. 2 and 3, to one end of a cam device consisting of a double-armed cam lever, 35, which is journaled on a pin, 36, below and adjacent to the segment 37 of the reverse lever 39. A curved slot, 41, is formed in the arm of the cam lever 35 opposite to that which is coupled to the distribution valve stem, said slot being located below and eccentric to the segment 37 of the reverse lever, and having upwardly curved cam ways 42 and 43 at its ends. A pin or bolt, 40, fixed to the reverse lever 39, traverses in the slot 41 and moves the cam lever 35 about its pivot 36 by its engagement with and disengagement from the cam ways 42 and 43, as the reverse lever 39 is moved into or out of either its extreme forward or its extreme backward position.

"The entrance of the pin 40 into either of the cam ways 42 or 43 depresses the arm of the cam lever 35 in which said cam ways and the intermediate slot 41 are formed, and elevates the opposite arm, thereby moving the distribution valve 30 to the right, and effecting the movement of the piston 6 in the same direction by the admission of motive fluid thereto through the then open passage 12. Such movement of the piston moves the connected converting valve mechanism into the position proper for the operation of the engine as a simple or non-compound engine, which operation is continued so long as the reverse lever remains at or closely adjacent to either extremity of its arc of traverse. By the movement of the reverse lever, in either direction toward the middle of its arc of traverse, for the purpose of cutting off steam at a desired point in the stroke of the pistons, as is practiced ordinarily after the train has been started, the pin 40 is moved into the portion of the slot 41 between the cam ways 42 and 43, elevating the arm of the cam lever 35 in which said slot and cam ways are formed and depressing the opposite arm, thereby moving the distribution value 30 to the left, and effecting the movement of the piston

FIG. 3.



7 in the same direction by the admission of motive fluid thereto through the then open passage 10. Such movement of the piston moves the connected converting valve mechanism into the position proper for the normal operation of the engine as a compound engine, which operation is continued so long as the reverse lever stands in such position or is so moved that the pin 40 remains out of contact with either of the cam ways 42 or 43. The cam ways may, if desired, be so proportioned that the pin 40 will remain in contact therewith when the reverse lever is moved one or more notches out of either of its extreme positions, and it will be noted that the rear cam way 42 is made of greater depth than the forward one 43 to accommodate the increased degree of movement of the cam lever 35 at and near its rear end, due to the greater distance thereof from the pivot 36 of the lever."

The above device is the invention of Mr. Daniel A. Wightman, of the Pittsburgh Locomotive Works. His patent is dated July 3, 1894, and is numbered 522,544.